TEACHING MATHEMATICS TO STUDENTS WITH LEARNING DISABILITIES AND STUDYING THAT INSTRUCTION USING A SINGLE SUBJECT DESIGN APPROACH

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of ANI DERDERIAN find it satisfactory and recommend that it be accepted.

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Abstract

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May 2013

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The primary purpose of this study was to examine a largely unexplored area of teaching strategies for students with mathematical learning disabilities. The second goal of this study was to examine whether the concrete representational abstract multisensory teaching map thinking strategy would increase mathematical achievement in students with mathematical learning disabilities. This study consisted of three students with mathematical learning disabilities from Amman, Jordan. Students were evaluated with 152 multiplication and division problems. This research involved the completion of a single subject design, which entails collecting numeric scores through tests. Next, the data was prepared and organized for graphical analysis. The analysis procedure described trends in data. However, the researcher used descriptive analysis, such as measures of variability, the spread of the scores, and the relative ranking of the scores. The results were presented in a graph and in a detailed discussion to address the research question. Additional, qualitative research was implemented with the three students. The researcher conducted the interviews, and eight open – ended questions were used for coding. The researcher then independently recorded the responses with the clarified themes. Four themes or categories of open – ended responses were identified (i.e., difficulties, number organization, memorization, language skill levels). The researcher recorded the data via a variety of methods (interviews, observation, field notes, etc.), coding and categorizing (using a variety of clustering and classification schemes), attaching concepts to the categories, and writing an understanding. However, the results suggest that more research might be needed in the following areas: (a) to replicate the study on different mathematical concepts and different subject areas; (b) arrange workshops for teachers and parents to increase their teaching effectiveness; (c) apply more tools such as case studies, interviews and self-assessment methods to assess the effectiveness level of mathematics teaching and learning strategies; (d) engage students with mathematical learning disabilities and consider their descriptions on the mathematics curriculum's effectiveness.

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CHAPTER ONE

INTRODUCTION

Needs for the Study

Today's classrooms have increasingly diverse student populations including students with widely different social, economic, cultural, and language backgrounds (Cirino & Fletcher, 2007). In addition, federal mandates have provided opportunities for students with a wide range of physical, cognitive, and sensory disabilities to participate in general education mathematics classes (Cirino & Fletcher, 2007; Stahl, 2004). For example, No Child Left Behind (2002) and the Individuals with Disabilities Education Act (IDEA, 2004) both delineated expectations and accountability for schools so that all students have access to (a) high quality learning, (b) the opportunity to participate in general education classrooms, and (c) learning experiences that allow them to make adequate yearly progress (AYP) toward states' standards. Unfortunately, many students with disabilities are failing to meet these expectations in mathematics (NCES, 2008).

Mathematics Learning Disabilities (MLD) are common, significant and worthy of serious instructional attention in both regular and special education classes (NCES, 2008). Students may respond to repeated failure with withdrawal of effort, lowered self-esteem, and avoidance behaviors. In addition, significant mathematic deficits can have serious consequences on the management of everyday life as well as on job prospects and promotion (Montague, 2007; NCES, 2008; Allosp, Kyger, lovin, Gerretson, Carson, & Ray, 2008). National and local studies reveal that youths with disabilities drop out of school at higher rates than the general population. As a result, students with disabilities are more likely to drop out than students without disabilities. Learning disabilities are the most commonly reported disability, affecting 2.2% of the U.S. population, or one third of the disabled youths in this age group. According to the NCES, the dropout rate for this group was 17.6 % in 2008.

Mathematics is one of the most difficult components of the school curriculum for students with learning disabilities (LD). According to the National Institutes of Health, 15% of the U.S. population, or one in seven Americans, has some type of LD (National Center on Educational Statistics [NCES], 2008). That is, the number of students with any disabilities, in thousands 2005-06 = 6.713 as for the students with specific LD as a percent of those with disabilities = 40.7 (NCES, 2008). As such, mathematics teaching has received increased levels of public scrutiny over the past decade (Evans, 2007; Miller, 2007). Cross-cultural comparative studies indicate that students in the United States have low performance in mathematics despite well-equipped classrooms, new curriculum, and professional teachers (Hiebert, Morris, & Glass, 2003). However, while the country as a whole is struggling, students with disabilities exhibit the most severe deficits (Fahsl, 2007; Maccini, Mulcahy, & Wilson, 2007). Even though 10% of U.S. 4th graders and 6% of U.S 8th graders scored at or above the advanced international benchmark compared to the international medians 5% in 4th and 2% in 8th grade, the students with special needs are still struggling in mathematics despite major amounts of expenditures that support special education classes (NCES, 2008).

The percentage of students -3 to 21 years old- served in federally–supported special education programs has risen over the past three decades, from 8 percent in 1976-1977 to 14 percent during 2005-2006. Much of the increase during this period can be attributed to the higher percentage of students identified with LD prior to 1990-1991 (NCES, 2008). Thus, the expenditures of elementary and secondary schools are $599 billion for 2006-07. As a result, expenditures for elementary and secondary schools rose by an estimated 38 percent between 1996-97 and 2006-07 (NCES, 2008). Interestingly enough, even though resources are spent, students with mathematics learning disabilities (MLD) are not showing improvement in mathematics.

Many elementary students struggle to understand mathematics because they have not developed an understanding of basic number operations (Lamon, 2006). Numerical concept is a branch of mathematics that uses mathematical statements to describe relationships between things that vary over time**.** These variables include things such as the relationship between supply of an object and its price. When we use a mathematical statement to describe a relationship, we often use letters to represent the quantity that varies, since it is not a fixed amount. These letters and symbols are referred to as variables (Algebra, 2011). However, elementary algebra is often part of the curriculum in secondary education and introduces the concept of variables representing numbers. Statements based on these variables are manipulated using the rules of operations that apply to numbers, such as addition. This can be done for a variety of reasons, including equation solving. The basic unit of an addition expression is a term. In general, a term is either a number or a product of a number and one or more variables. Figure 1 represents the term –3+x

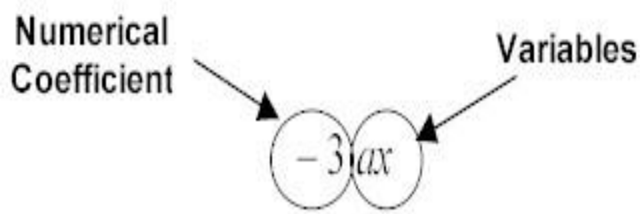


Figure 1. Term -3ax

The numerical part of the term, or the number factor of the term, is what is referred to as the numerical coefficient (Algebra, 2011). This numerical coefficient will take on the sign of the operation in front of it. The term above contains a numerical coefficient, which includes the arithmetic sign, and a variable or variables. In this case the numerical coefficient is –3 and the variables in the term are *a* and *x*. Terms such as xz may not appear to have a numerical coefficient, but they do. The numerical coefficient is 1, which is assumed.

Not surprisingly, students with LD have more difficulty meeting the mathematics grade-level standards than the general school population (Miler & Mercer, 1997). More than 60% of students with LD in reading also have significant disabilities in mathematics (Light & DeFries, 1995). Thus, language disabilities, even subtle ones, can interfere with mathematic learning. In particular, many students with LD have a tendency to avoid verbalizing in mathematical activities, a tendency often exacerbated by the way mathematics is typically taught. Developing verbalizing mathematical practices, examples and procedures can greatly help in removing obstacles to success in mainstream mathematical settings (Light & DeFries, 1995). However, these students have more difficulties in acquiring mathematics skills than their peers and need different learning strategies (Miller & Mercer, 1997).

Research over the past decade (Cawley, Parmar, Foley, Salmon & Roy, 2001) has focused on identifying specific deficit areas for students with MLD. For example, Browder, Spooner, Ahlgrim-Delzell, Harris, and Wakeman (2008) found that most of the studies in the literature addressed numbers and computation or measurement. These studies offered strong evidence for using systematic instruction to teach mathematics skills. In another recent study, Fuchs, Seethaler, Powell, Fuchs, Hamlett, and Fletcher, 2008 indicated that students with MLD struggle when focusing on mathematical structure, recognizing problems, solving word problems and transferring problem-solving skills to problems that include irrelevant information such as two-digit operands, missing information in the first or second position and calculation skills for basic problem solving (Fuchs et al., 2008).

Further research indicates that students with special needs are being included in general education classrooms at an increasing rate. There has been a seven percent increase in the number of students who are fully included in general education classroom over the past decade (U.S. Department of Education, 2007). Many teachers have expressed concern about their ability to effectively educate students with special needs due to lack of knowledge, training, and experience, as well as the additional preparation and collaboration time involved (Fahsl, 2007; Lin, 2008). Teachers also worry that accommodating students who are at risk in terms of developing MLD and require remediation make it difficult to provide appropriate instruction for the rest of the students in the class (Fahsl, 2007).

Allosp, Kyger, Lovin, Gerretson, Carson, and Ray (2008) noted that the experiences of students' with MLD both in and out of school have influences on their academic achievement. Also, as students become more proficient in mathematics, their attitude toward mathematics and their academic self-concept improve (Allosp et al, 2008). When students become more competent and feel better about their mathematic performance, they gain more confidence and become more motivated, which increases their chances of success. Therefore, mathematical proficiency is essential not only to success in school, but also to success in adult life (Montague, 2007).

Certainly, mathematics competence has been associated with successful employment and higher income upon service (Rivera-Baltiz, 1992). Still, less than one-third (31%) of fourth-grade students in the United States scored at or above the proficiency standard on the 2003

National Assessment of Educational Progress in mathematics (Manzo & Galley, 2003). Likewise, over 50% of students with learning disabilities in United States' schools have Individualized Educational Program (IEP) goals that focus on mathematics (Lerner, 2003). This is critical, given that without direct intervention, learning disabilities in mathematics tend to continue into adulthood (Miller & Mercer, 1997). Nevertheless, interventions for children with mathematics disabilities receive less attention than children with reading disabilities (Badian, 1999; Burns, 2005; Daly & McCurdy, 2002). Therefore, teachers of students with learning disabilities need access to instructional strategies to provide children with more opportunities to apply skills to real world contexts. This will help students to communicate mathematically, which will support mathematics learning (Foegen, 2008; Gagnon and Maccini, 2006).

Children with disabilities need to be protected in special settings (Kavale and Forness, 2000). Special interventions or placement options would be determined based on specific diagnosis of disabilities to treat students' deficits (Vaughn, Gersten, and Chard, 2000). The main criterion for eligibility to receive such special education interventions has been a proof of intrinsic deficit (Aldridge, 2008). Traditional special education supporters believe that children with disabilities cannot receive appropriate educational services in regular education classrooms and argue that special education has an important role of identifying students who may need more specialized forms of intervention compared to those students who do not need such practices (Kauffman, 2007). For this reason, various countries such as Sweden, Japan, and Jordan adopted the traditional teaching approach.

Diverse groups of people from surrounding countries rely on Jordan's special education centers, bringing their children with special needs to receive learning and rehabilitation services to those centers. These services include: (a) early intervention services; (b) day care services; (c) inclusion services; (d) assessment and diagnostic services; and (e) rehabilitation and vocational services such as community based rehabilitation services under the supervision of United Nations Relief and Works Agency (UNRWA). The country of Jordan provides a representative model of the diversity of people with special needs. The World Bank estimates that there are 196,000 to 524,000 individuals with disabilities in the Hashemite Kingdom of Jordan (United Nations, 2009).

Brief History on Education in Jordan

Higher education in Jordan began in the 1960's, when numerous colleges for teachers were established throughout the country. Their establishment provided necessary teaching manpower to meet the high demand on school education characterizing the era (Hashemite Kingdom of Jordan Ministry of Higher Education [MOHE], 2005). Additionally, while the principle for general education in Jordan states that: "Everyone has a right to a free and public education," those with disabilities are missing from the list of protected people. Moreover, the educational services in Jordan are introduced to everyone equally and without any discrimination based on sex, language, ethnicity, and religion (Jabery & Zumberg, 2008).

In 2003-2004, the Ministry of Education (MOE) indicated that the number of schools in Jordan reached over 5,000. In addition, there were approximately 77,000 teachers, and 1.5 million students, of which there was almost equal representation of males (51%) and females (49%) (Ministry of Education [MOE], 2004). Table (1) illustrates these statistics.

Table 1

General Education Statistics 2004/2005

	Male	Female	Total

Teachers	30,775	46,167	76,946
Students	768,475	746,840	1,515,315

Table 1 depicts the general education system in Jordan, considering the number of teachers and students. Additionally, it compares gender ratios of student and teacher numbers. It is clear that female teachers are more numerous than male teachers. Moreover, the general education system includes some special considerations that affect the teaching and learning process, and focuses on the well-being of all students. These considerations are illustrated in the following figure:

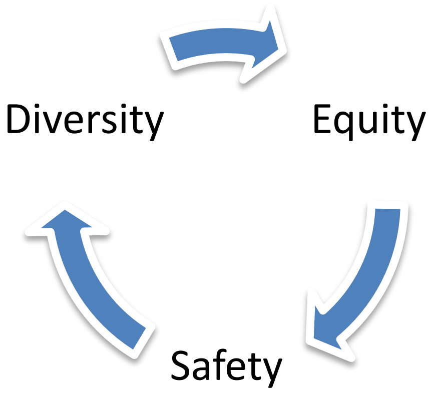


Figure 2. Teaching and Learning Considerations

Equity of opportunities means providing equal opportunities for all students by providing opportunity-based programs since the schools need to emphasize that outcomes are available for all on an equal basis (Catts & Lau, "UNESCO, National Reports," 2008). Diversity focuses on students' special needs that affect their learning capacity. These special needs can be quite clear such as physical disabilities or may be less obvious such as learning disabilities. Therefore, schools need to adopt learning processes to meet the diverse needs of these students (Catts & Lau, "UNESCO, National Reports," 2008). The concept of safety emphasizes that all students should feel safe at school, and different subjects require different standards of safety that curricula specialists should consider (Catts & Lau, “UNESCO, National Reports,” 2008).

Special Education

Educational policies in Jordan must take into consideration the necessity to provide basic and comprehensive services for students with special needs. Initial services for special education were implemented at the end of the 1960s. At this time, an institute was established in Jordan offering services to persons who are deaf, blind, or mentally impaired (Jabery & Zumberg, 2008). Inclusion remains a questioned concept in educational policy in Jordan because it relates to social values. However, any argument about inclusion should address some essential questions:

- Do we assess all children equally?
- What do we mean by "inclusion"?
- Are there some children for whom "inclusion" is unsuitable?

Inclusion is a term which expresses assurance to educate each child, to the maximum extent appropriate, in the school and classroom he or she would otherwise attend. It involves bringing the support services to the child rather than moving the child to the services and requires only that the child will benefit from being in the class. There are advocates on both sides of the matter. Some view inclusion as a policy driven by an unrealistic expectation that money will be saved. Furthermore, supporters of this approach argue that trying to force all students into the inclusion mold is just as tough and discriminatory as trying to force all students into the mold of a special education class or residential institution (Baker, Wang & Walberg, 1995; Park, Chae, 2005). In contrast, those who support inclusion believe that the child always should begin in the regular environment and be removed only when appropriate services cannot be provided in the regular classroom regardless of what those needs may be (Baker, Wang & Walberg, 1995; Yongsoo, Hee-Tae, 2005). Between the two borders are large groups of educators and parents who are confused by the concept itself. They wonder whether inclusion is legally required and wonder what is best for children. They also question what it is that schools and school personnel must do to meet the needs of children with disabilities.

Jordan uses specialized centers to address students' needs, while the U.S. tends to use inclusion (Kavale & Forness, 2000). Japan uses both. Scandinavian countries previously used inclusion and have now returned to using specialized centers. This is related to policies and economic issues in addition to education.

Purpose of Study

The primary purpose of this study is to examine a largely-unexplored area, the method of teaching strategies such as the concrete representational abstract with map thinking teaching strategy for students with mathematical learning disabilities in Jordan. The second goal of this study is to examine similarities and differences in these students' mathematical achievements.

Research questions:

The proposed study will investigate how students use technology as they develop concepts related to numbers. For this purpose, the following question will be answered:

Is there a functional relationship between concrete representational abstract-based with map thinking teaching instruction used in mathematics curriculum for 45 minutes per day and increases in numerical mathematical problem solving for fifth graders with mathematical learning disabilities?

Assumptions

1. Mathematics questions are valid and reliable. The instruments are reliable and valid for students with mathematical learning disabilities.
2. Fifth grade school students have a comprehension ability to read and accurately answer the questions.
3. The translated Wood-cock Johnson Test version is valid.
4. Students participating in this study will provide an honest effort in answering those instruments.
5. The researcher who will collect data in Jordan will conduct the data collection following the procedures.

Delimitations

1. Size and nature of sample.
2. Geographic location of students.
3. Possible sampling bias.
4. Format of multiple baseline design.
5. Researcher’s background.

Terms

Concrete (do): the students use concrete objects to model problems.

Representational (see): the students use representations of the objects, such as drawings, to model problems.

Abstract (use symbols): the students use abstract symbols to model problems.

Map-thinking: teaching strategy using drawing (see Appendix D).

Significance

There may be several contributions of this study. First, different teaching strategies with students with mathematical learning disabilities have been explored. From a theoretical perspective, the findings are consistent with previous studies confirming that various teaching strategies could support students with mathematical learning disabilities. Generally speaking, students with mathematics learning disabilities need to utilize the senses altogether from seeing the number, hearing the sound it makes, writing the number in the air, touching the sandpaper number, and drawing the letter really large on the carpet, and this will help improve the memories of the students with mathematical learning disabilities. The success of employing the multisensory strategy (visual, auditory, kina-static, and tactile (VAKT) lies in the fact that a student with learning disabilities is not limited to visual and auditory experiences but can make use of other areas of the brain in trying to establish clear memories of numbers that are difficult to remember.

Second, this study may provide information about whether the concrete representational abstract teaching strategy is more important and helpful for students with mathematical learning disabilities. This is important especially for the Jordanian students with MLD, who learn through representational and abstract methods due to lack of resources.

Third, from a practical perspective, mathematics is important for an individual’s future career. It is important for both technology and social science. There are different ways to help students with mathematical learning disabilities to better achieve in mathematics and have good experiences in learning mathematics. Findings from this study may help us understand how students with mathematical learning disabilities learn and have better attitudes toward learning mathematics. The results of this study may be beneficial for parents, teachers and researchers. Decades of research have proved that parental engagement in schooling is a promising means through which students' educational outcomes can be increased (Howland, Anderson, Smiley, & Abbott, 2006; Mattingly, Prislin, McKenzie, Rodriguez, & Kayzar, 2002). Various studies have connected parental involvement with students' achievement (Stevenson & Baker, 1987), more steady school attendance (Epstein & Sheldon, 2002), and fewer discipline problems (Sheldon & Epstein, 2002). From this study we may have a better understanding of mathematical teaching strategies for students with learning disabilities and thus better identify and focus research towards methods to help these students gain value for meaningful and appropriate mathematics achievement.

CHAPTER TWO

LITERATURE REVIEW

Mathematics Difficulties

Mathematics is one of the most challenging aspects of school curriculum for students with learning disabilities (LD). However, a strong background in mathematics is critical for many career and job opportunities in today's increasingly technological society. Understanding the characteristics of students with LD and then clarifying their needs leads to successful learning experiences. The Learning Disability Act (LDA) defined learning disability as a neurological disorder that affects one or more of the basic psychological processes involved in understanding or in using spoken or written language. The disability may manifest itself in an imperfect ability to listen, think, speak, read, write, and spell or to do mathematical calculations (Kavale and Forness, 2000). Additionally, people with learning disabilities are generally of average or above average intelligence. There seems to be a gap between the person's potential and actual achievement (Kavale and Forness, 2000). Thus, there is no cure for a learning disability.

As early as 1950s and 1960s, Kilpatrick labeled the era as "the golden age" in the field of mathematics education because of the extensive federal funding in the United States for research and training in mathematics (Kilpatrick, 2009). A number of forces shaped this era, the most well-known being the importance of mathematics to development of atomic weapons in the 1940s and the launch of Soviet Sputnik in 1957. America responded with a surge in federal funds to produce more scholars, teacher educators, and highly prepared mathematics teachers who would help the U.S. compete internationally (Kilpatrick, 2009). Steelman's (1947) presidential report, *Man Power for Research*, articulated the need for the successful school mathematics programs that would eventually increase the number of engineers and other highly technically prepared workers needed for a more scientifically-oriented society. This report was indicative of the kind of high profile, policy documents that would appear over the next 50 years, ones urging education to produce more technically literate workers for an evolving economy (Kilpatrick, 2009). However, at the same time higher education in Jordan began with numerous colleges for teachers established throughout the country. Their establishment provided necessary teaching manpower to meet the high demand on school education characterizing the era (Hashemite Kingdom of Jordan Ministry of Higher Education [MOHE], 2005).

Miller (2007) reported that students with LD enrolled in 12th grade performed at a high 5th grade level in mathematics, students with LD aged 9 through 14 demonstrated very little progress in computation from one year to the next, and students with mild learning disabilities (LD) demonstrated computational performance considerably lower than their general education peers (Miller, 2007). Cawley et al. (2001) described the arithmetic performance of students with mild LD in addition to their non-disabled peers and discussed their data in terms of student achievement and its implications for standards and programming. The data were obtained across grade levels 3-8 on 937 general education students and 197 students with mild LD. The data was discussed in terms of selected mathematics standards. Current mathematics guidelines emphasize the importance of establishing mathematics standards for both students with and without disabilities (Usher, 2011; National Council of Teachers of Mathematics [NCTM], 2000).

According to the NCTM, mathematics curricula should include five content areas: (a) numbers and operations, (b) algebra, (c) geometry, (d) measurement, and (e) data analysis and probability. Within each of these content areas, NCTM suggests that five process standards be integrated: (a) problem solving, (b) reasoning and proof, (c) communication, (d) connections, and (e) representations. The practitioner level mathematics movement is supported with legislation (e.g., Individuals with Disabilities Education Improvement Act of 2004; No Child Left Behind Act of 2001) mandating increased academic performance expectations for students with and without disabilities. All students are now required to demonstrate annual yearly progress (AYP) toward grade level expectations (Miller, 2007). Schools and districts where students fail to do so are at risk of state or government level intervention (Abedi & Dietel, 2004). Special educators must be able to utilize diverse instructional strategies that facilitate students' with MLD understanding of mathematics standards (i.e., numbers, algebra, geometry, measurement, data analysis, and probability) to promote learning and help students meet AYP expectations (Miller, 2007; Montague, 2007).

Research-Based Strategies for Students with MLD

Students understand mathematical concepts at different levels: concrete, representational and abstract (CRA), but they do not always possess understanding of concepts at all three levels. Students with MLD face the most significant challenges when they are asked to apply mathematical concepts at an abstract level (Allosp et al, 2008; Sood & Jitendra, 2007). CRA is an intervention for mathematics instruction. It can enhance the mathematics performance of students with LD. It is a three-part instructional strategy mentioned by Allosp et al (2008), with each part building on the previous instruction to promote students' learning. On the other hand, there is flexibility between these levels; for some students, it's easy to move from the 1st level to the 3rd level: for others it is more difficult (Montague, 2007).

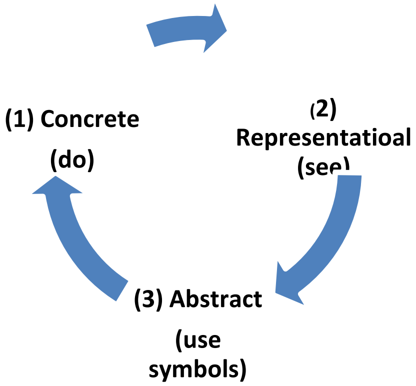


Fig 3. The relationship between CRA levels.

Figure 3 illustrates the relationship between the three CRA levels. In the concrete stage, the students use concrete objects to model problems. In the representational stage, the students use representations of the objects, such as drawings, to model problems. As for the abstract stage or symbolic level, the students use abstract symbols to model problems (Allosp et al, 2008) and then the levels circle back from the abstract level to the concrete and representational levels. For this reason, various instructional strategies might be used to implement mathematics lessons including individualized mathematics teaching, cultural approach with explicit vocabulary building, and daily re-looping of previously learned material. Consequently, the performance of students with mathematical learning disabilities will be upgraded at the elementary, middle, and secondary school levels. Moreover, those instructional strategies will help the students with LD develop mathematics competence in an effective and efficient way (Miller, 2007; Montague, 2007).

Additional instructional strategies have been validated with students with emotional behavioral disorders (EBD) and LD in mathematics. First, graduated instruction, which refers to a three-phase approach to mathematics that includes (a) a concrete phase that is representing concepts via objects, (b) a semi concrete phase that is drawing pictures of objects, and (c) an abstract phase that is using numerical representations (Gagnon, Maccini, 2006). Second, the use of grouping practice such as cooperative learning activities, which promote academic success for secondary students with EBD and LD. For example, class wide peer tutoring was effective practice in teaching algebra problem solving skills to 14 and 15 year old students (Gagnon, Maccini, 2007). Likewize, Calhoon and Fuchs (2003) investigated the effects of Peer-Assisted Learning Strategies (PALS) with elementary school students as a supplemental instructional technique to improve computation and concepts applications skills.

The final instructional strategy is self-monitoring. This strategy helps students to monitor their problem-solving behaviors via self-questions while solving a problem (Maccini and Gagnon 2006).

In a different study, Maccini, Mulcahy and Willson (2007) examined a number of practices that demonstrate significant gain for secondary school students with LD in mathematics, including mnemonic strategy instruction, graduated instructional approach, cognitive strategy instruction involving planning, schema-based instruction, and contextualized videodisc instruction. In their study Maccini et al. (2007) implemented behavioral interventions, including: (a) a drill and practice procedure; (b) a direct instructional approach; (c) intersperse assignment tasks; and (d) a conceptually based instructional approach. These behavioral interventions focus on basic mathematics facts, rules, and procedures for middle school students with learning or mathematics disabilities.

Hence, Test and Ellis (2005) explained the Mnemonic strategy as an instructional practice that refers to “a word, sentence, or picture device or technique for improving or strengthening memory.” Moreover, mnemonics can be classified as facts to help students recall fast or process in order to remember steps, processes, or rules (Test and Ellis, 2005).

Moreover, Maccini et al. (2007) described the graduated instructional sequence by a three-phase process that implies: (a) concrete instruction which means introducing students to concepts via manipulative; (b) semi concrete or representational instruction that is gradually advancing pictures to represent objects; (c) abstract instruction which advances to abstract mathematical tasks by using numbers and symbols. This instructional cycle is generally referred to as either the CRA sequence or the concrete-semiconcrete-abstract (CSA) sequence (Maccini et al., 2007).

Equally important, Naglieri and Johnson (2000) researched the effects of a cognitive planning strategy on the mathematical performance of students identified as poor planners. The researchers based their study on the Planning, Attention, Simultaneous, and Successive (PASS) theory, which supposes that there are four basic processes for planning and successfully accomplishing cognitive tasks. These four processes are: (a) planning, for the task by self-monitoring while solving the mathematical problem; (b) attention, by focusing while solving the problem; (c) simultaneous, by addressing and using various data or information at the same time to solve the problem; (d) successive, by solving a mathematical problem in some specific order (Maccini et al., 2007). The purpose of this study was to determine whether children with cognitive weakness in each of the four PASS processes and children with no cognitive weakness showed different rates of improvement in mathematics when given the same group planning strategy instruction. The children with a cognitive weakness in planning were shown to improve considerably over baseline rates, while those with no cognitive weakness improved only marginally. Similarly, there were substantially lower rates of simultaneous, successive, and attention. The importance of this study was that the five groups of children responded differently to the same intervention. In other words, the PASS processing scores were predictive of the children's response to this mathematics intervention (Naglieri and Johnson, 2000).

In addition to the use of PASS, Jitendra, Hoff and Beck (1999) in their study addressed schema-based instruction (SBI). They mentioned that this instructional process involves explicit instruction that focuses on helping learners understand the structure of the mathematical word problem such as the proportion and the comparison. The authors investigated the effects of SBI with middle school students with mathematical learning disabilities and difficulties on one and two step addition and subtraction word problem performance. Jitendra et al. (1999) found that students with LD utilized previously mastered skills or concepts to solve related problems when they were provided a review of background skills or concepts in mathematics. Furthermore, these students were able to develop more complex, integrative and elaborative problem-solving skills in mathematics with greater fluency.

Ozaki, Williams and McLaughlin (1996) examined the effects of a copy / cover / compare (CCC) procedure on the multiplication fact mastery of a sixth-grade student with LD. Another study conducted by Wildmon, Skinner, Watson and Garrett (2004) demonstrated the effects of interspersing simple computation tasks into computation problem assignments on the accuracy, completion, and perceptions of seventh and eighth grade students with MLD was investigated. For the same reason, Scalato and Burr (2002) pointed out the effects of a direct instruction (DI) approach for teaching fraction and decimal skills to middle school students with LD.

Maccini and Gagnon (2000) determined that special and general education teachers of secondary students with LD and EBD noted using a number of empirically practical approaches for teaching mathematics to the students with learning disabilities. These approaches included the following: (a) use of objects for conceptual understanding; (b) peer or cross-age tutoring strategies; and (c) organizational strategies for retention such as cue cards of strategy steps, graphic organizers, mnemonics, and time for additional practice. Maccini and Gagnon (2000), found that teachers noted using other instructional practices with students with LD and EBD in mathematics such as; (a) use of calculators; (b) assignment modifications as adjusted workloads; and (c) increased time for activities and tests. In addition to these instructional practices, they emphasized the assignment modifications procedure which was practiced by reducing class work problems, homework problems and adjusting the workload via color coding or circles for cuing. Although these practices have yet to be validated with students with LD and EBD, they were frequently noted, perhaps because they are recommended in special and general education textbooks. For example, in an introductory text for teaching mathematics to students with special needs, experts recommend using visual cues and reduced class work and homework problems (Maccini & Gagnon, 2000). These recommended practices probably help mathematics teachers plan and implement instruction that is beneficial for all students and help teachers from "spending an inordinate amount of time with one child to the exclusion of others" (Bley & Thornton, 2001, p. 22). Though cited by teachers in a statewide investigation (Maccini & Gagnon, 2000; Impecoven-Lind & Foegen, 2010), no national studies exist that focus on teachers' use of empirically validated and recommended instructional practices to assist secondary students with LD and EBD in mathematics.

Mathematical Teaching Strategies

Lamon (2006) and Allsop et al. (2008) characterized mathematical teaching strategies typically used by teachers: (a) accelerated or individualized mathematics (this is a system of having student work at different levels); (b) adjusted speech (that is the teacher changes speech patterns to increase students' comprehension); (c) daily re-looping (process of previously learned material is an integral part of instruction); and (d) ecological approach (enhancing the generation of data from real life experiences to use in class). This involves all aspects of a child's life, including classroom, family, neighborhood, and community in teaching the child useful life and educational skills; (e) explicit timing which involves timing mathematic seatwork; and (f) explicit vocabulary building through random recurrent assessments, such as using brief assessments and tests (Lamon, 2006; Allosp et al, 2008).

The following diagram illustrates the mathematical teaching strategies that improve the CRA levels.

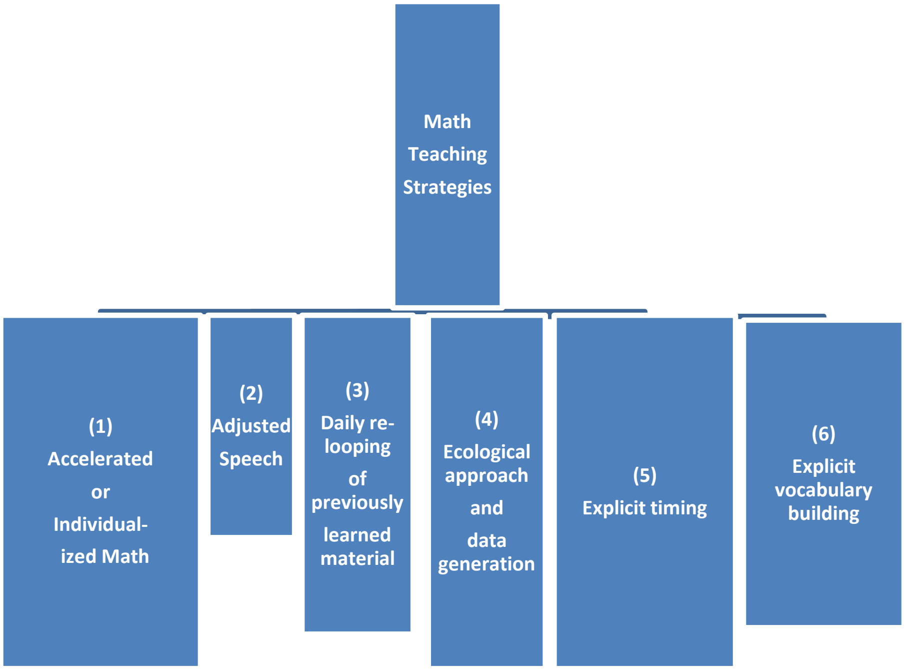

Math Teaching Strategies
(1) Accelerated or Individual-ized Math
(2) Adjusted Speech
(3) Daily re-looping of previously learned material
(4) Ecological approach and data generation
(5) Explicit timing
(6) Explicit vocabulary building

Fig 4. Mathematics Teaching Strategies

These strategies improve the CRA levels and help students move to more abstract ways of solving problems. The various strategies reviewed help students with mathematical learning disabilities to better understand mathematics as they need special modified learning strategies, Thus, a theoretical framework for improving access to curricular materials is using diverse instructional strategies such as those described previously (Rose, Meyer & Hitchcock, 2006).

Instructional Technology

Technology provides multiple means of representation, expression, and engagement (Rose et al, 2006). For example, representing a mathematical concept both in text and graphically supports learning and provides multiple, flexible methods of expressions by using a variety of media to help recognize individual differences (Rose et al, 2006). These strategies support effective mathematical learning, where many students experience difficulty bridging informal mathematical knowledge to formal school mathematics (NCES, 2008). To build these connections takes time, experiences, and carefully guided instruction. The use of structured, concrete materials is important to securing these links, not only in the early elementary grades, but also during concept development stages of higher-level mathematics (NCES, 2008). Some students need particular emphasis on the translation between different written forms, different ways of reading these and various representations (objects or drawings) of what they mean (NCES, 2008).

Technology can increase the interactions between students, and create multiple means of representation, expression, and engagement within the context of the classroom (Fuchs, Mock, Morgan & Young 2003; Puckett, 2004; Rose et al, 2006). Fixed uniform learning materials make it difficult for teachers to meet the individual needs of students because they are rigid and do not meet the needs of different students. Few teachers have either the time or expertise to adequately adapt the curriculum materials to meet the diverse needs of their students (Ellis & Sabonie, 1990; Mceneaney, Lose & Schwartz 2006; Meo, 2008). Technology can also help students with learning disabilities organize and represent their data through the creation of a variety of graphs and geometric constructions (Lin, 2008; Marchand, 2010). For example, technology such as software programs that essentially scans text to create an audio version of a book and a graphing can be helpful for students with MLD. Technology can help students with MLD draw and represent their mathematical understanding. Therefore, the use of technology is essential in the representational stage of CRA teaching strategy.

Technology can provide new accessible materials for all students, especially for children with MLD, by converting the hard copy into digital forms. Digital images can help children with MLD focus attention on the mathematical ideas in addition to using concrete manipulative, which are often used in mathematics classrooms to explain the CRA levels and the continuous movement between these levels. In addition, digital images assist student learning by providing visuals, screen readers, and computerized manipulatives (Stahl & Aronica 2002; Sood & Jitendra, 2007).

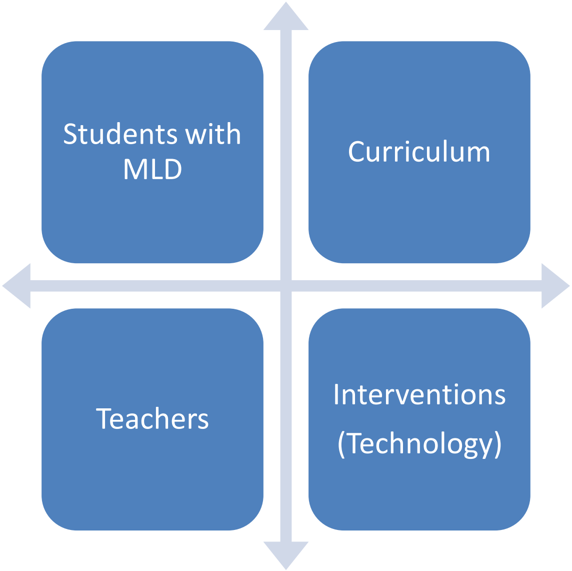


Fig 5. How Technology Supports a Mathematics Curriculum

Figure 5 highlights how technology supports a mathematic curriculum.

Its primary objective is to support students with MLD by using technological resources (Hardy, 2008).

Given the difficulties that most students with LD and EBD experience with mathematics (Maccini, Gagnon, 2000), it is important to identify the instructional practices and assessment accommodations that help these students succeed in mathematics and have access to the general education mathematics curriculum in a significant way (Maccini et al., 2007; Maccini and Gagnon, 2006). A previous review of the literature (Maccini & Hughes, 2000) provided support for a number of practices, including peer-mediated interventions, technology-assisted instruction, strategy instruction, contextualized lessons, and use of self-monitoring techniques (Maccini et al., 2007). However, the use of these specific instructional practices to help teach mathematics to students with learning disabilities and emotional / behavioral disorders is a continuous challenge for teachers in today's schools (Miller, Butler, Lee, 1998). In a similar study, Maccini and Gagnon (2006) showed that general education teachers are generally more knowledgeable about higher level mathematics content (e.g., algebra) than special education teachers. However, they are less likely to use specific instructional practices and testing accommodations (Maccini, Gagnon, 2006).

The Mathematic Dynamic Assessment (MDA) is an early screening instrument that can be beneficial in helping teachers choose appropriate mathematics programs and curriculum for students with MLD (Gerson, 2005). Early identification and the use of technology from the early stages of childhood will help MLD students learn mathematics (Dugan, Campbell and Wilcox, 2006; White and Gerson, 2005). The use of screening and technology (Hardy, 2008) can help teachers plan instruction that meets students' needs as they teach concepts and skills related to the key mathematics focal points (Allosp et al, 2008; Hardy, 2008; Montague, 2007). Kunch, Jitendra and Sood (2007) theorized that if we change instructional pedagogy, make adjustments to classroom programs, and train teachers for future work, students, teachers and parents can overcome MLD difficulties.

Mathematics Deficits Consequences

MLD difficulties are common, significant and worthy of serious instructional attention in both regular and special education classes (NCES, 2008). Students may respond to repeated failure with withdrawal of effort, lowered self-esteem, and avoidance behaviors (Allosp et al, 2008). In addition, significant mathematics deficits can have serious consequences on the management of everyday life as well as on job prospects and promotions (Allosp et al, 2008; Montague, 2007; NCES, 2008). National and local studies reveal that youths with disabilities drop out of school at higher rates than the general population. LD was the most commonly reported disability, affecting 2.2% of the population, or one third of the disabled youths in this age group. The dropout rate for this group was 17.6% (NCES, 2008).

A theoretical framework for improving access to curricular materials is using diverse instructional strategies such as those described previously (Fuchs, 2003; Hardy, 2008; Rose et al, 2006). Response to Intervention (RTI) promises to offer earlier, more relevant help for students at risk for LDs (Brown-Chidsey, and Steege, 2005; NCLD, 2006) and provide critical information about the instructional needs of the student, which can be used to create effective educational interventions (Hardy, 2008; NCLD, 2006; Ofiesh, 2006). The following graph illustrates a three-tier RTI model.

Tier (1)	Tier (2)	Tier (3)
22 students	18 students	18 students
5 at risk	4 students	3 students

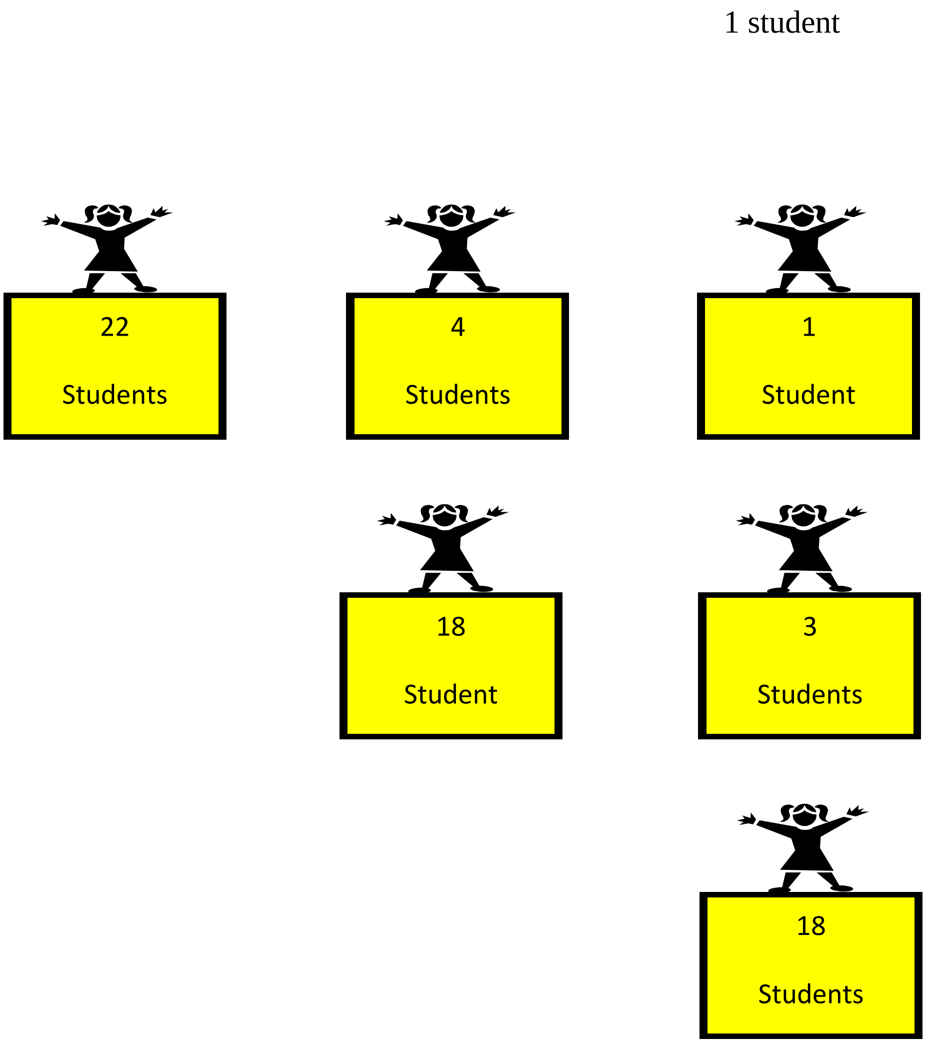


Fig 6. A Three-Tier Response to Intervention (RTI) model

The previous RTI model represents three tiers. Tier (1) includes the screening and grouping interventions. Tier (2) shows the targeted interventions. As for tier (3) it includes the intensive interventions and the comprehensive evaluations (NCLD, 2006; Marston, 2005). The progress students make at each stage of intervention is closely monitored. Results of this monitoring are used to make decisions about the need for further research-based instruction and / or intervention in general education, in special education or both (NCLD, 2006).

The three-tier RTI model includes three stages. Tier one consists of screening and group interventions it is also known as general instruction and assessment (Brown-Chidsey, and Steege, 2005; NCLD, 2006). Students who are at risk are identified using screening, tests, and progress monitoring. Identified students receive additional interventions, generally delivered in small groups in the regular classroom. At the end of this tier, students showing considerable progress are returned to the regular classroom program. Students not showing sufficient progress are moved to tier two (NCLD, 2006). Tier two presents targeted interventions for students not making adequate progress it is known as supplementary instruction and assessment (Brown-Chidsey, and Steege, 2005; NCLD, 2006). More intensive services are provided to students in small group settings, in addition to instructions in the general curriculum. Students who continue to show too little progress at this level are considered for tier three which is a more intensive intervention (NCLD, 2006). Tier three includes intensive intervention as well as comprehensive evaluation also known as specialized instruction and assessment (Brown-Chidsey, and Steege, 2005; NCLD, 2006). In this stage, students receive individualized intensive interventions that target the student's abilities and deficits. Students who do not respond to these targeted interventions are then considered for special education programs (NCLD, 2006). RTI supports making what is abstract and intangible, concrete in order to bridge the gap between the concrete world and the abstract world of concepts (Fuchs, 2003; Rose et al, 2006). RTI- based curricula supports effective learning by providing flexible options and broadly accessible curricula (Fuchs, 2003; Meo, 2008; Puckett, 2004; Rose et al, 2006; Sood & Jitendra, 2007).

In addition to the use of effective and diverse instructional strategies, teachers should consider the use of RTI as a way to help students with MLD access information and compensate for their unique processing abilities. RTI is beneficial for students in the regular classroom (Allosp et al, 2008; Ofiessh, 2006). In IDEA (2004), RTI is described as a means to improve the functional capabilities of students with MLD. For example, RTI allows students to see a graphical representation of the slope of a line. This would provide the student with the information necessary to explain how changing rise/run in the equation influences the slope of a line (Garderen, 2007).

Moreover, RTI can make manipulation of concrete representations more accessible and help students' transition from concrete to abstract levels of understanding (Garderen, 2007). For example, many students with MLD confuse the concept of area within the "whole" when comparing fractions with different denominators. The fractions represent parts of a whole, but students with MLD often have difficulty recognizing that the wholes must be equivalent in size in order to make an accurate comparison (Allosp et al, 2008; Sood & Jitendra, 2007). Thus, RTI can be a helpful tool to illustrate this concept to students by allowing students to create accurate drawings in the general classroom (Garderen, 2007).

In fact, RTI yields beneficial results for all students if the instructional methods are scientifically based and accurate data about student progress are collected frequently (Brown-Chidsey and Steege, 2005; Mceneaney et al, 2006).

The following figure highlights how RTI supports students with MLD

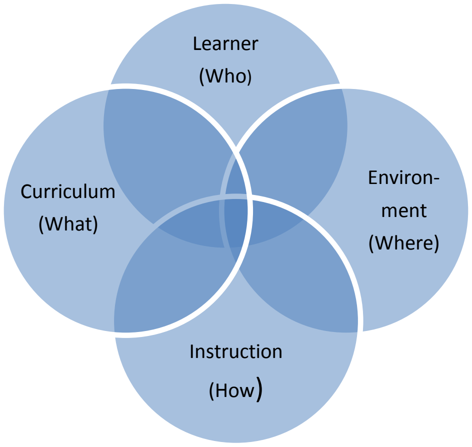


Fig 7. Response to Intervention (RTI) model and MLD students

This model's primary objective is to support students with MLD (Hardy, 2008). Further, to improve the student's mathematical outcomes educators, policy makers, developers and publishers of new hardware and software should work closely to conduct new high-quality curriculums with a strong technology component, and meet students need at every level (Montague, 2007; Hardy, 2008). Moreover, curriculum refers to what is taught. This domain includes the long range direction, intent, and stated outcomes of the course of study. As for the instruction it refers how the curriculum is taught. This domain includes instructional decision making regarding materials and curriculum level. Once an appropriate curriculum is implemented, instruction should be examined for effectiveness starting with the whole group.

Also, the environment is where the instruction takes place (Fuchs, 2003), including all aspects of the classroom setting such as physical arrangement, rules, management plans, routines, and expectations. It may also include out of class variables such as peer and family influence. Lastly, the learner who is being taught, the most important variable of which is his or her current knowledge, sometimes referred to as "prior knowledge" of the task that they need to learn (NCLB, 2006; Fuchs, 2003). Therefore, the use of effective pedagogy is essential.

Multi-Sensory Pedagogy

Studies from the National Institute of Child Health and Human Development (NICHHD) have shown that a Multi-Sensory teaching method is the most effective strategy for teaching children with learning disabilities (Multisensory Teaching Methods, 2011). Using Multi-Sensory teaching strategies helps children to learn through the use of more than one of the senses. In fact, Multi-Sensory instruction is a technique that relies on the use of multiple senses, which will help children learn in a combination of visual, auditory and kinesthetic means. Incorporating these three components will lead to a better learning. Most teaching in schools is done using either sight or hearing through utilizing the visual or the auditory senses. The child's sight is used in reading information, looking at diagrams or pictures, or reading what is on the board. The sense of hearing is used in listening to what the teacher says. A child with learning disabilities may experience difficulties with either or both these senses which causes difficulties in tracking and learning (Multisensory Teaching Methods, 2011). In addition, MLD students experience weakness in memorizing facts and procedures and this puts them at a disadvantage during mathematics instruction (Behrend, 2003).

Multi-Sensory instruction has its roots in the Orton-Gillingham (O-G) approach (Gillingham & Stillman, 1997) and is the basis of a number of remedial reading programs, such as Alphabetic Phonics, the Herman Approach, the Slingerland Approach, the Spalding Approach, and the Wilson Approach (Colony, 2001). In this situation, Multi-Sensory refers to the use of visual, auditory, and kinesthetic senses (VAKT) in the remediation of reading disabilities. Moreover, in 2001, The International Multi-Sensory Structured Language Education Council (IMSLEC) published a compilation of clinical studies of Multi-Sensory structured language instruction for students with reading disabilities. In this collection, they specified both the content and strategies used in Multi-Sensory structured language programs (Giess, 2005). In the following illustration, we can see the relationship between the three VAKT components.

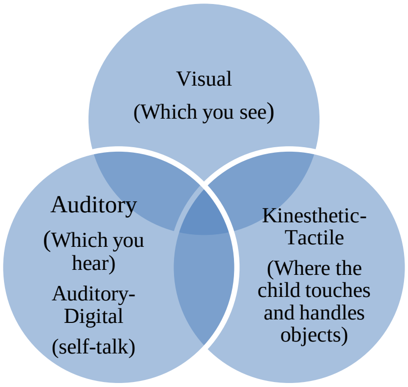


Fig 8. The Multi-Sensory or the Visual, Auditory, and Kinesthetic-Tactile (VAKT) Method

Figure 8 illustrates the three Multi-Sensory elements. The visual elements help the students using their sight and considered visual learners. For example, learning with media such as television, computers, and multimedia environments, could be used as a complementary teaching process. In this way, visual representations are constructed and learning procedures are performed. These media are distinguished by cognitively relevant characteristics of their technologies, symbol systems, and processing capabilities. Thus, these instructional designs interact with learners and influence the structure of mental representations (Kozma, 1991). Second, the auditory elements help the students use their hearing as self-talk strategies. For example, teaching the child to talk through mathematic problems, saying and repeating the problems softly to themselves, without disturbing others is taught. As a result, this will make use of auditory as well as visual memory abilities, skills and proficiency as the brain can store different kinds of memories. As for the kinesthetic or the tactile elements, the students touch and handle objects (Multisensory Teaching Methods, 2011). The method circles back from the kinesthetic stage to the auditory and visual stages to complete the VAKT cycle. This method incorporates different tools to stimulate all the senses rather than just seeing and hearing; such as, coloring fractions, using small colored cubes to describe the fraction questions or using them to help in answering the questions are commonly done (Al-Hroub, 2010). The reason for using the Multi-Sensory instructional method is that many students who appear to do well in mathematics but have specific learning difficulties, have problems in some areas of mathematics due to perceptual and or short-term memory weaknesses (Al-Hroub, 2010). However, many of these areas of difficulty may be overcome by applying the Multi-Sensory method in enhancing the students’ with mathematical learning disabilities memory and learning (Al-Hroub, 2010). For this reason, using the Multi-Sensory or the VAKT method when implementing mathematics lessons will improve mathematics performance of students with mathematical learning disabilities (MLD) at the elementary, middle, and secondary school levels (Simon & Hanrahan, 2004).

Kroesbergen and Van Luit (2003) described the general characteristics of learning disabled students. They mentioned that these students have memory deficits leading to difficulties in the acquisition and recall necessary for developing mathematics skills. Moreover, these students often show inadequate use of strategies for solving mathematics tasks. In addition, students with MLD show deficits in generalization and transfer of learned knowledge to new tasks. Therefore, it has been recommended to use new and different effective forms of instruction (Kroesbergen & Van Luit, 2003) such as the VAKT instructional pedagogy.

VAKT Instruction

An example will make this clear; the majority of students' with MLD often confuse the numbers "9" and "6." The students argue that they can both be seen as a stick with a circle at its base and definitely cannot give the right direction. Using the Multi-Sensory method with its three components will be beneficial in the teaching process. However, a teacher might give a tactile (touchy / feely) experience of the number "9" by getting the children to draw the number really large on the carpet. This will involve the children using their arms, their sense of balance, and their whole body movement. The children will remember this experience and will use this memory the next time they need to write the number (Using Multisensory Teaching Methods, 2011). Using different teaching materials such as sandpaper and letting the children run their fingers over the number "9" will support the children's tactile memory. Writing the number "9" on a paper or in the air will be a helpful visual tool. Finally, using play-dough or clay will also give strong tactile memory of the number "9."

Another example is how to differentiate between the following signs: greater than ≥ or smaller than ≤. Here, the teacher can use visual drawing tricks to explain the concept. For example the instructor can say that the wide opening is toward the big number and the small opening toward the small number such as, 6 < 9. The result of these activities will help the children to learn through Multi-Sensory method from seeing the letter to hearing and eventually touching it as the sandpaper example where the children experienced the body movement process or the kinesthetic element in the VAKT method (Using Multisensory Teaching Methods, 2011). In the following illustration, we can see the VAKT teaching technique which utilizes different natural senses.

Fig 9. Fingerithmatic as a Multi-Sensory Technique

Figure 9 illustrates a Multi-Sensory technique that uses all the natural senses. Moreover, this strategy turns the fingers into a calculator, by using the three components of the VAKT method. Furthermore, students with MLD can utilize the visual, vocal-auditory, and the touch senses. In short, this VAKT strategy can help students with MLD who have difficulty understanding mathematics and other learning concepts, by enhancing their memory. In general, the previous examples from students with MLD highlight and emphasize the importance of implementing the Multi-Sensory method in mathematics classes (Behrend, 2003).

Theoretical underpinning and research based practices of Multi-Sensory pedagogy

Many researchers believe the recent changes and variation in the instructional procedure hold great promise for educational development and growth (Ojose, 2009). In fact, instructional knowledge is often considered an important tool for bringing about organized, efficient and systematic changes (Ojose, 2009). Many educators believe that applying the VAKT method will improve their students' thinking skills. Teachers will be able to change the way they run their classroom and students will become more involved and will enjoy learning (Ojose, 2009).

Research suggests (Ojose, 2009) that students who use the Multi-Sensory method as a primary resource are better able to understand the applications of mathematical principles. When students are able to explore mathematics in a variety of ways and are not confined to a specific strategy, they will be able to develop a rich understanding of the mathematical concepts. Moscardini (2009) showed the importance of a practical artifact tool in a classroom which supports the learning and teaching in mathematics with evidence that students develop mathematical understanding through interacting with objects and by working with materials. However, there is a danger that using only one component from the VAKT method may inhibit students' adequate understanding.

Using all components of the VAKT method enhances students' procedural and conceptual understanding in mathematics. Conceptual and theoretical knowledge relates to "knowing why" and involves an understanding of the system of mathematical relationships and connections. Procedural and technical knowledge explains "knowing how to" and defines the procedures to be carried out (Moscardinin, 2009). In short, within the field of mathematics the development of a Multi-Sensory pedagogy underpinned by practical theory will help students with MLD to use their senses to show and develop meaningful learning. These students will benefit from the use of more of their senses, especially the use of touch and movement, which will give their brain tactile and kinetic memories to depend on, in addition to the visual and auditory ones they encounter in traditional mathematics classrooms (Using Multisensory Teaching Methods, 2011).

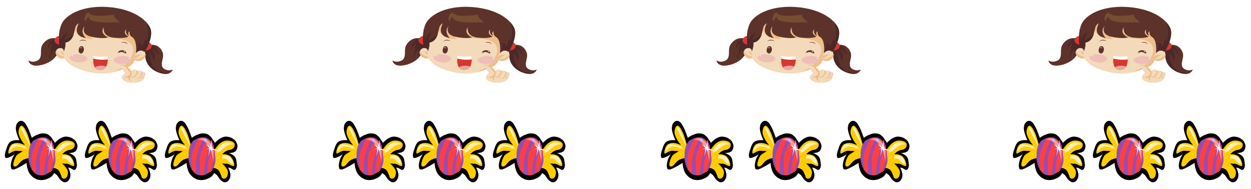
The human brain can learn things that do not come naturally. Learning could be achieved through advanced pedagogy processes. Utilizing different senses and concentrating on the Multi-Sensory or the VAKT pedagogy is what Samuel Orton and Anna Gillingham examined. Orton and Gillingham used the term Multi-Sensory to describe their program for the students with reading disabilities (Multisensory Structured Language, 2011). Yet, another way to give a strong perceptible memory of numbers such as the number “12” and the number “21”, which most of the students with learning disabilities have difficulty in distinguishing. Therefore, it is easy for them to make the number out of clay or play-dough. A frequently used method to remember the direction of “12” and “21” is to show the child the number on a card and use stories to help the students with MLD memorize the directions.

Al-Hroub (2010) explained Multi-Sensory remedial strategies that could be provided to all students in general classroom settings. Furthermore, using this approach will facilitate differentiated learning and gives a sense of enjoyment through visual, auditory, and motor-tactile techniques. It will also help teachers focus on students’ strengths and support them to become excited about school and mathematics classes and topics, in addition to providing remedial work in the student’s area of difficulty. It may result in students reading and exploring mathematics as a subject of interest.

Nurnberger-Haag (2003) presented a mathematics lesson using the “Order of Op Hop” to teach the order of operations. This lesson uses a map that resembles a hopscotch board to teach the order both visually and kinesthetically. Learning a mathematical process like the order of operations is extremely difficult. The Order of Op Hop helps prevent students from getting lost as they work their way through problems. Furthermore, since many students are visual or kinesthetic learners, giving them the opportunity to learn this order by hopping or walking through a map often helps them remember the sequence. Addressing these multiple learning styles, can benefit all students in the class (Nurnberger-Haag, 2003).

In addition to the Op Hop method, other strategies also were studied. Scott (1993) used the Touch Math program, which involves teaching the students using three procedures: visual, auditory, and kinesthetic. Touch point instruction in all three procedures supports the learning process and improves the students with MLD knowledge with the addition and subtraction problems, and enables them to solve these problems rapidly, accurately, and without frustration.

In fact, Moscardini (2009) explained through examples from classroom observations how students with MLD used manipulatives and in some cases graphic representations to solve word problems. For example, the following problem, 29 - (4x5) = y would be a challenging problem to MLD students with no prior experience of formal multiplication problems. In this problem, the VAKT method will be helpful. The teacher can explain through concrete materials as having 29 sweets. Four children will take 5 sweets each; and by counting the left over sweets, the problem will be solved. Fig 10 depicts the above example. Moreover, in the following illustration we can see the importance of the Multi-Sensory method in teaching pre-algebra



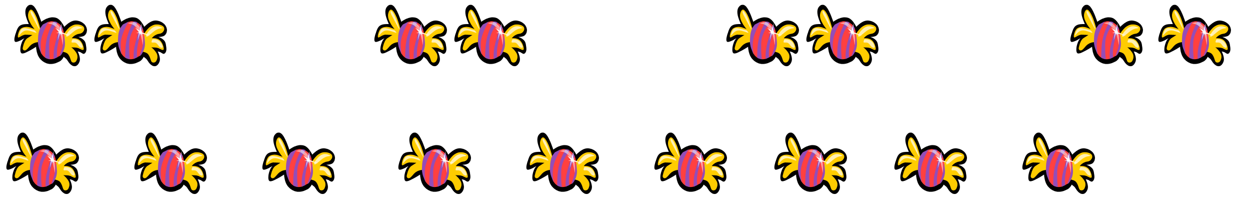


Fig 10. Multi-Sensory method to teach pre-algebra

Another example to teach algebra utilizing the VAKT method will be the following problems. Through drawing these problems on a board the student will utilize the visual and kinesthetic senses, which will support algebraic mathematical problem solving and processing:

$6\ (7+X)$ $\quad$ Y^2+7 $\quad$ $4X+2$ $\quad$ $bh \div 2$

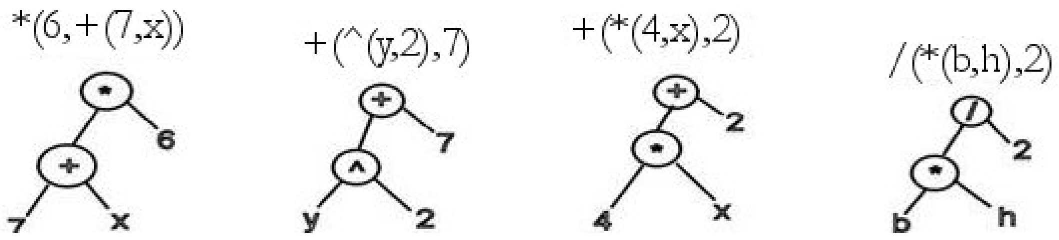


Fig 11. Multi-Sensory method to teach algebra

Figure 11 illustrates algebraic examples that are solved through a visual-kinetic-tactile method. This method is effective and efficient among students with MLD and helps special learners to make special connections in mathematics and, more importantly, increases their sense of mathematical power in a general, inclusive and mainstreamed class setting (Funkhouser, 1995).

Although many learning disabled students receive instruction for reading and mathematics in resource settings such as special education resource rooms, still others receive all or part of their basic instruction in general education classrooms. For this reason, and for these students, it is often recommended that teachers implement instructional adaptations such as the usage of the Multi-Sensory pedagogy (Kluwin and Kelly, 1992). Applying the Multi-Sensory method through the stimulation of different senses will help students to perform many learning tasks that involve localizing and tracking moving objects. Therefore, it is likely that the human brain has evolved to learn, operate and develop in Multi-Sensory environments. Hence, Multi-Sensory teaching method is more effective for learning (Shams & Seitz, 2008). In this situation, encoding, storing and retrieving perceptual information is intended to better operate in a Multi-Sensory environment. On the other hand, uni-sensory processing often does not operate perceptual machinery to its fullest potential. Therefore, employing the VAKT strategy within the natural classroom settings will improve the performance of students with learning disabilities (Shams & Seitz, 2008). VanDerklok’s (2006) study, suggested that recognition of events through convergence of visual and auditory cues is accomplished through a network of brain regions that was previously implicated only in visual recognition of action.

In another study (Laurienti, Burdette, Maldjian & Wallace, 2006), the authors suggested the use of Multi-Sensory channels to represent an effective teaching strategy that overcomes uni-sensory deficits. The authors also explained the reflective influence that the different senses (visual, auditory, and kinesthetic-tactile) can have on our perceptions, awareness and observation. It is only through the appropriate incorporation and integration of information from different senses that a meaningful and accurate perception of learning occurs. For this reason, fitting the Multi-Sensory model in mathematics classes and applying it to the students with MLD would support their learning efficiency. Thus, this would support the procedural competency in mathematics and would have a guarantee of understanding and achievement (Moscardini, 2009).

What might Multi-Sensory pedagogy look like in a mathematics classroom?

Many students with MLD experience difficulties in some areas of mathematics such as sequencing, operations, fractions, decimals, percentages, ratios and statistics. Many still need to learn the basics, for example, how to count forwards and backwards. For this reason, it is very important to teach each concept thoroughly and in detail before moving on to the following idea. Apparently, students with MLD need extra instruction especially as new concepts are introduced. Therefore, to help students with MLD, the first thing teachers need to be aware of is how much they know or understand about the topic and this cannot be assumed because of age or grade.

Regularly, a problem with short-term memory can make it particularly hard for students with MLD to learn multiplication and sequencing. Hence, to help these students teachers need to follow a task analysis procedure, and this means to follow the teaching process step-by-step and never to move on to another concept until the student is ready for it. For example, never to move on to counting backward until basic counting has been mastered. Multi-Sensory teaching approach would be very helpful to teach students with learning disabilities in this context. In this method, using games to keep the students active by utilizing their different senses would enhance their learning abilities and enable them be engaged to their full potential. On the other hand, if the students become tired or bored at any point, changing or moving the activity to a different one or sometimes taking a short break would be effective and useful.

In addition to applying games, a teacher can utilize the VAKT method by having the students with MLD interact and move. For example, one game-backed method includes arranging 100 counters in a long line on the floor and having them place a marker after each ten. The student can then practice counting all the way through to one hundred. Moreover, teaching tens by using a different colored counter in place of the tens number can be helpful. After that, the students can learn to count by fives. The counting of numbers by ten and five will help the students when they move to other skills such as, multiplication and telling time. After the students accomplish this skill they can start to count backwards. Practicing counting can be used in any situation; for example, counting cars as they pass by or stairs as they climb up.

Another exercise that can be done anywhere—in the classroom or at home—is to call out a number and have the student call out the following one. At first the hardest numbers for the child to remember are usually where there is a change of tens, as in 19 to 20 or in 29 to 30 etc. In this case it will be helpful to use the VAKT method with emphasis on the kinetic stage where the student can actually apply physical and kinetic counting strategies.

Multiplication and division are the most difficult for students with MLD to master. However, it will make it easier for a student to learn if they understand the concept. For example, if the teacher defines the concept through visual, auditory, and kinetic demonstrations the students will move between the concrete, representational and abstract levels. To start a multiplication problem the students can collect five pairs of items, gloves, shoes, toy animals, or anything as long as the pairs are the same. Second, the students can recognize the similar pairs and can tell that one pair has two items, two pairs has four items, etc. When the student sees the five pairs have ten items, the teacher should explain what 5x10 means. This exercise can be repeated with each of the different pairs until the students understand what the “2 times” means. Once the student is familiar with the 2 times table, they should begin to work on all the tables in the following order: 2x, 10x, 11x, 5x, 4x, 9x, 6x, 7x, 8x, then finally 12x, which they should know from the other tables.

1	2	3	4	5	6	7	8	9	10
2	4	6	8	10	12	14	16	18	20
3	6	9	12	15	18	21	24	27	30
4	8	12	16	20	24	28	32	36	40

5	10	15	20	25	30	35	40	45	50
6	12	18	24	30	36	42	48	54	50
7	14	21	28	35	42	49	56	63	70
8	16	24	32	40	48	56	64	72	80
9	18	27	36	45	54	63	72	81	90
10	20	30	40	50	60	70	80	90	100

Fig 12. Multiplication Table

Figure 12 shows the multiplication process and is considered an extremely helpful tool for students with MLD. In addition, using worksheets and pictures of familiar animals or items for students to count will help students with MLD to remember multiplication facts. An example of this is if a student knows 8x5 well, they can learn 9x5 by counting up by five. Moreover, connecting mathematical story problems to things that students like, such as, nature, family, the environment, and games will increase the visualizing level of the VAKT method.

Additionally, games work remarkably well for students with MLD. Children enjoy playing Bingo. Teachers can use multiplication Bingo game by making Bingo type cards on a piece of paper, filling the squares with the answers to all the multiplication facts, up to 6x6 with regular dice, 9x9 and 12x12. Lastly, the students will take turns to roll the dice; multiplying the two numbers rolled and marking it off on the players' Bingo sheets.

Another helpful tool that can be used for students with MLD is a calculator. Students should not use the instrument to do all of their mathematical calculations, but to check their answers and make corrections where necessary. Mathematics teachers should help students by reviewing the concepts regularly as students with MLD have difficulty in remembering and retaining the details. Without the teachers help, mathematics class can be very frustrating for both general and students with MLD. When teachers are empowered to make decisions backed up by the administration, a level of trust grows which allows for greater innovation and more effective teaching. An individual who feels empowered and involved in the decision-making process will not only have greater job satisfaction, but will also be better able to accept decisions with which they might not agree. As mentioned previously, this starts with the principal and the shared main values that all relate back to determining what's best for students. A school where teacher opinions are not valued and they feel powerless will result in discontented teachers who do not have the desire to put as much into their teaching (Algozzine & Ysseldyke, 1992). Moreover, researchers point out specific characteristics of effective special education teachers such as experience, practical work, teaching methods and strategies, implementation of pre and post assessment, parent-teacher interaction (Algozzine & Ysseldyke, 1990).

Rosenberg and Sindelar (2003) suggested, “There is a general recognition that valid and explicit professional standards are necessary for teacher preparation” (Geiger, Crutchfield, & Mainzer, 2003, p.3). However, in a recent report, the U.S. Department of Education (USDE) reviewed relevant literature and concluded that teachers’ general cognitive ability, experience and content knowledge are the variables most strongly associated with teacher effectiveness. On the other hand, teachers’ training, doing practice teaching, earning master’s degree and teacher certification requirements have not been seen to be associated with student achievement (United States Department of Education [DE], 2003; Paige, 2002).

Lastly, many computer games are exciting and provide an excellent means of mathematics practice, beginning with basic Multi-Sensory instruction, sequential and arranged small steps, verbalization and visualization techniques, and review and practice. These games can help students with MLD utilize their abilities to the maximum potential (Babbitt & Miller, 1996).

What is a Big Idea in mathematics?

According to Michael Bassis (1946) **“**It isn’t enough just to learn—one must learn how to learn, how to learn without classrooms, without teachers, without textbooks. Learn, in short, how to think and analyze and decide and discover and create.” (p. 17).

This quote illustrates several things about mathematics, for example, thinking, creating and discovering. Thus, teachers need to understand the big ideas of mathematics and be able to represent mathematics as a coherent and connected enterprise (NCTM, 2000, p. 17). Teachers are being encouraged more and more through statements such as the one above to teach to the big ideas of mathematics. Yet, if you ask a group of teachers or any group of mathematics educators for examples of big ideas, you will get quite a variety of answers. Some will suggest a topic, like equations, others will suggest a strand, like geometry, while others will suggest an expectation, such as those found in Principles and Standards for School Mathematics (NCTM, 2000), and some will even suggest an objective, such as those found in many district and state curriculum standards. Although all of these are important, none seems sufficiently robust to qualify as a “big idea” in mathematics. A proposed definition of a big idea will be as an idea or a statement of an idea that is central to the learning of mathematics, one that links numerous mathematical understandings into a logical whole (Herbel-Eisenmann & Breyfogle, 2005).

This definition helps teachers and leads to effective mathematics teaching which consists of understanding what students already know and what they need to learn, and then assisting them to learn it correctly (NCTM, 2000). Therefore, teachers who understand the big ideas of mathematics apply that to their teaching practices by consistently connecting new ideas to these big ideas and by reinforcing big ideas throughout their teaching. Moreover, research is beginning to identify important characteristics of highly effective teachers (Stigler & Hiebert, 2004; Weiss, Heck & Shimkus, 2004; Ma, 1999). For example, effective teachers facilitate high-level classroom conversations, accessing students' thinking and understanding during lessons.

To conclude, explicit, systematic instruction involves extensive use of visual representations, and therefore is considered a strong approach for supporting mathematical learning for both low-achieving students and those with MLDs (Ketterlin-Geller, Chard & Fien, 2008). Additionally, students benefit when they are encouraged to think aloud while they work or share their thinking with peers (Ketterlin-Geller, Chard & Fien, 2008; Herbel-Eisenmann & Breyfogle, 2005). Teachers pose a variety of questions to their students. However, some questions promote deeper mathematical thinking than others. For example, when asking, "Is there another way to represent or explain what you are saying?" students are given a chance to justify their thinking in multiple ways. Whereas the question "What did you do next?" focuses only on the procedures that students followed to obtain the answer (Herbel-Eisenmann & Breyfogle, 2005).

Another instructional process could affect students' MLD learning is the type of practice designed in mathematics interventions. Questions still remain about the most effective intervention program for students with MLD based on their needs (Ketterlin-Geller, Chard & Fien, 2008).

Principles and strands for school mathematics (NCTM, 2000) challenges teachers to "encourage students to think, question, solve problems, and discuss their ideas, strategies, and solutions" (p.18). Asking students to express their thinking is hard and needs specific questions to be posed. This teacher-student interaction allows for discussion to accomplish the lesson goals and helps students with MLD articulate their thinking, contribute to classroom interaction and develop their mathematical skills (Ketterlin-Geller, Chard & Fien, 2008; Herbel-Eisenmann & Breyfogle, 2005).

In addition to the six instructional practices described above, other practices are effective. For example, the Concrete-Representational-Abstract (CRA) strategy helps students, particularly students with MLD in elementary and secondary schools (Ketterlin-Geller, Chard & Fien, 2008; Witzel, 2005; Witzel, Mercer, & Miller, 2003; Witzel, Smith, & Brownell, 2000; Maccini & Hughes, 2000). Concrete instruction is centered on students learning through hands-on manipulation and may focus either on concept or procedures. After students learn through concrete instruction, they learn to model mathematical problems using representations such as drawings. Finally, they develop fluency in mathematics and reach the abstract level where they use symbols (Ketterlin-Geller, Chard & Fien, 2008).

Students understand mathematical concepts at different levels, concrete, representational and abstract (CRA), but they do not always possess understanding of concepts at all three levels. Students with MLD face the most significant challenges when they are asked to apply mathematical concepts at an abstract level (Allosp, Kyger, Lovin, Gerretson, Larson & Ray 2008; Sood & Jitendra, 2007). CRA is an intervention for mathematics instruction. It can enhance the mathematics performance of students with MLD. It is a three-part instructional strategy mentioned by Allosp et al, with each part building on the previous instruction to promote students’ learning (Allosp et al, 2008).

With effective instruction, many students with MLD are able to better learn and utilize mathematical concepts during the initial instruction but find it difficult to maintain those skills over time. Maintenance of mathematical knowledge can be facilitated by new meaningful teaching strategies such as the VAKT method (Ketterlin-Geller, Chard & Fien, 2008; Maccini & Gagon, 2000; Mercer, Jordan, & Miller, 1994). An important goal for mathematics teachers is to organize experiences for students with MLD that will help them better understand and learn mathematics, and specifically will promote algebra reasoning to elementary and secondary students (Bishop, Stump, and Britton, 2003).

Multi-Sensory pedagogy holds promise to support students with MLD

Students generally appreciate the opportunity to explore mathematics. Some students need more conceptual understanding of mathematics. Hence, educators can utilize different methods and strategies to help students with MLD. For example, implementing the Multi-Sensory method will develop students with MLD abilities and skills in mathematics and therefore will lead to better learning. Students with mathematical learning disabilities need different teaching methods in order to better learn. The following comment reflects students' with MLD need for different teaching strategies:

> Although I have many experiences with algebra, I have still learned important algebraic ideas this semester. One of the ideas I feel I have learned is the importance of identifying why particular variables go together in the way they do in problems. Before this class, I would write equations and pay no attention to the explanation of why the equation was written the way it was. By completely understanding the equations written, the problem has much, more algebraic meaning (Strump, Bishop, Brittoni, 2003, p.180).

The previous excerpt shows how students appreciate and understand mathematics if teachers use varied teaching strategies. Moreover, different instructional practices help students to learn mathematical skills. Maccini and Gagnon (2000) determined that special and general education teachers of secondary students with MLD and Emotional-Behavioral-Disorders (EBD) noted using a number of empirically practical approaches for teaching mathematics. These approaches included the following: (a) use of objects for conceptual understanding; (b) peer or cross-age tutoring strategies; and (c) organizational strategies for retention, such as cue cards of strategy steps, graphic organizers, mnemonics, and additional practice. Moreover, other students reflect on how these learning experiences may be helpful to them as in the following student's quote:

> I have learned that solving an algebraic problem is more than just finding the correct answer, but also understanding how one derived that answer and where each part of the formula comes from. One must be concerned with the answers to the questions "What is the answer to this problem?" and also "Why is that the answer to the problem?" (Strump, Bishop, Brittoni, 2003, p.180).

The preceding comment reflects how students are often positive in their own knowledge of mathematics, but they still need deeper understanding of the context. Students with mathematical learning disabilities often struggle to clearly communicate their knowledge and understanding of mathematics therefore teachers need to try various strategies and select numerous activities to help motivate students with MLD. The challenge for teachers is to choose special mathematical teaching methods that will thoroughly develop the students' skills.

Multi-Sensory method is one method that utilizes the different senses, and therefore could help the students with MLD to learn to their full potential. Students with mathematical learning disabilities students have special characteristics that teachers should consider. Table 2 illustrates these characteristics:

Table 2

Characteristics of MLD students

Math	Study Skills
Difficulty memorizing basic facts	Poor organization and time management
Confusion or reversal of numbers, number sequence, or operational symbols.	Difficulty following directions
Difficulty reading or comprehending Word problems	Poor organization of notes and other written materials
Problems with reasoning and abstract concepts	Students need more time to complete assignments

Most people with learning disabilities learn to adapt to their learning differences, and adopt strategies that help them accomplish their goals and dreams (Kavale and Forness, 2000). For this reason, applying the VAKT method could help MLD students who are seen as less capable than they actually are. However, their general ability to learn is comparable to or higher than many of their peers; these students simply have specific skill weaknesses in some areas. In many ways, students with learning disabilities have creative problem solving skills and can perform well with appropriate and specially designed instruction. Therefore, using visual tools such as diagrams, graphics and pictures, which support the learning process, in addition to the auditory and kinetic procedures.

CHAPTER THREE

METHODOLOGY

Subjects

A random sample of three fifth grade students with mathematics and reading difficulties from a private school in Amman, Jordan was interviewed. All of the children met Jordan's Ministry of Education criteria for special education eligibility as students with learning disabilities on the basis of reading and mathematical test scores, in addition to Princess Rahma's Learning Disability eligibility test. The researcher focused on students with low performance in mathematics and reading because, given the correlation between mathematics and reading, deficits in both areas are likely to produce severe academic deficits that are especially difficult to remediate. In addition to Princess Rahmah Learning Disability Tests, test results from previous tests conducted in the school were used to identify students with difficulty in reading and mathematics.

Table 3

Summary of Demographics for 5th Grade Students with MLD

Subjects	Age	Gender	Grade	Strength	Challenges	Specific Diagnosis
1st student	10	Male	Fifth	Art	Mathematics	LD
2nd student	10	Male	Fifth	Sport	Mathematics	LD
3rd student	11	Male	Fifth	Sport	Mathematics	LD

Procedures

The study took place in two parts: First, investigating the notions that elementary school students have about number operation. Second, designing instructional process to help students understand mathematics and evaluate the effectiveness of the instruction.

The school principal was contacted and introduced to the study. After receiving permission from the school principal, the investigator chose students randomly and sent a written consent form for the students parents to sign (see Appendix A), a written assent form for student to sign (see Appendix B) and pre-test questions for students to complete (see Appendix C). The questions included mathematical number operations such as multiplication and division.

Students in Jordan were given the questions in Arabic language. Therefore, appendixes A, B, C and D and test questions were translated into Arabic. The first mathematical session required the student to complete a set of assessment activities so that the results could be compared to a replication of the assessments at the end of the program to determine if improvement was made.

The concrete representational abstract method by using thinking maps was administered during the second semester of the school year. The researcher administered the test. See Table 4.

Table 4

Data Collection Matrix-Type of Information by Source

Subjects of Study	Results	
	Number of Correct Answers	Number of Wrong Answers
1st student	68 / 152	84 / 152

2nd student	107 / 152	45 / 152
3rd student	98 / 152	54 / 152

The school special education teacher helped by providing the IEPs as well as the previous results on Princess Rahma tests adopted from Woodcock-Johnson III test.

The Woodcock-Johnson III reports, recommendations, and strategies were used to assess children with mathematical learning disabilities. The following subtests results were used to screen students:

Table 5

Woodcock-Johnson subtests

Subtest	Focus	Example
Test 5	Math fluency	Basic and simple
Test 6	Applied problems	Measures math achievement, Existing skills, automatic skills
Test 10	Applied problems	Measures math achievement and knowledge. Requires analysis to solve problems. May indicate poor knowledge, instruction comprehension or reasoning.

Test 18	Quantitative concepts	General knowledge of math and the ability to inductively and deductively reason with concepts and properties.
Test 17	Reading vocabulary and comprehension	Reading vocabulary at an isolated word level. Poor performance may indicate limited reading skills and word comprehension.

The researcher collected the data by administering one-on-one paper and pencil-based tests. Each question was read aloud and also allowed the student to see the problem, with the researcher providing students time to complete work before progressing to the next item. Data was collected by using a record sheet, by taking notes. The researcher kept a record of mathematical difficulties the students had on a day-to-day basis in a notebook, for the purpose of correcting these difficulties during later sessions and for recognizing types of changes in progress over time.

The paper and pencil based-assessment questions related to different numerical concepts and represented a mathematic level of ability that is slightly above that which the students' assessment results indicated; mathematic paper and pencil-based questions posed a slight challenge to the student. As the student solved the problems, the teacher documented the results by taking notes on the multiplication, division and self-correction of the questions. Once a level was completed, the teacher filled in the number of mistakes the student made in a Table 4.

The premise of the paper and pencil-based questions was that the level of difficulty might be just above the students' level of mastery with the aim of giving the student the element of challenge, and therefore, strategizing through the paper and pencil-based activity with the result of improving performance.

To assess the impact of paper and pencil-based instruction strategy on the mathematical outcomes, a visual analysis was administered. The final analysis focused on the mathematical outcomes at the paper and pencil-based testing strategies and compared the magnitude of the effect sizes for students with mathematical learning disabilities.

Phase 1: Three fifth grade students were withdrawn from their class to complete a paper and pencil-based mathematical assessment, which assessed mathematical numerical understanding over a four-day period to determine a baseline level of mathematical ability. Phase 2: Following Phase 1, the researcher administered a concrete representational abstract-based map thinking teaching method (independent variable) with the first student (see Appendix D). At the end of the baseline period for this student, this procedure was repeated with the second and third student. The students then completed the activities each day and fulfilled a mathematical assessment to determine the students' proficiency with numerical concepts (dependent variable) following each lesson (see Appendix E). Probe: Two weeks after the termination of the program, the assessment was repeated with each of the three students for two days to show the effectiveness of the intervention after its completion (Creswell, 2008).

Treatment fidelity checklist

During baseline formation and following each daily session with the students, the researcher completed the following checklist to document to what degree students were completing aspects of this intervention:

Table 6

Concrete representational abstract [CRA]-based mathematics teaching treatment fidelity

Check (/) If completed	Treatment Fidelity Criteria
(/)	Student solved CRA-based mathematical problems in the baseline Phase as well as in the treatment and follow up phases.
(/)	Based on the errors/difficulties, the student completed some activities to overcome difficulties.
(/)	Student completed some work with mathematical activities on number concept.
(/)	The student read and solved paper and pencil-based mathematics Problems.
(/)	The student solved higher-level mathematical problems.

Inter-Rater Reliability

A special education teacher in the school was assigned to complete the Treatment Fidelity Checklist every third day during baseline formation, treatment, and follow-up so as to provide evidence of accuracy of the checklist's data collected by the researcher.

Social Validity

From the perspective of social comparison, students were chosen due to their difficulties in mathematics. The intervention addressed those difficulties and compared students with MLD to peers who do not need the intervention.

Three social validity levels were addressed:

1. *Social Comparison.* The researcher worked in a team that consists of teachers, parents, school administrators, students, and mathematic experts to examine the concrete representational abstract-based mathematics teaching method and provided feedback on its viability in terms of helping students with mathematical disabilities to improve their mathematical skills. The researcher asked the team to comment on the degree that this strategy would be useful to students with MLD, given that the intervention happened during class time.
2. *Social Appropriateness of Procedures.* A questionnaire was used in order to determine if the program is appropriate for students with MLD. The students, the classroom teacher, and the parent(s)/guardian(s) completed the questionnaire (see Appendix G).
3. *Social Appropriateness of Effects.* The researcher asked for feedback from the classroom teacher, student, and parent(s)/guardian(s) at the end of the study to determine the effectiveness of the intervention. This was done through the questionnaire or (see Appendix G).

Validity

Multiple Baseline design controls for threats to internal validity by (a) comparing simultaneous versus staggered implementation of Independent Variable (IV), (b) comparing Series 2, Series 3 and Series 4, (c) comparing concurrent versus non-concurrent Multiple

Baseline design, and (d) exploring efficiency options through documenting the four series with effects at three points in time.

Concurrent data shows that baselines occur together in real time, while, for non-concurrent data, the baselines occur at different times.

Instruments

Gains in the achievements of students with MLD were evaluated by data collected from measures of paper and pencil-based tests specifically measuring the students' abilities and levels of understanding to solve problems in mathematics.

The 8 test questions used for this research were taken from a teaching resource, *"Algebra 4 Children, Exercises and Materials for Teaching Math."* Fifth grade level multiplication and division questions were accessed through the following link: http://www.algebra4children.com/Algebraic_expressions_1.html

The primary data collection instrument was a test with 8 questions. The questions that were used in the test were paper and pencil and technology-based to assess the concrete, representational and abstract levels in mathematics. Eight different mathematical questions related to mathematics were used for the test. The three students separately answered the questions. The researcher then analyzed the results. This technique served as a good indicator for determining the importance of using technology with students with mathematical learning disabilities.

Design

Teaching mathematics for students with mathematical learning disabilities was addressed by using concrete representational abstract teaching method. The researcher used thinking maps to teach numerical concepts such as multiplication and division. (see Appendix D). Quantitative data was collected and analyzed. This research involved the completion of a single subject design, which entails collecting numeric scores through tests. Next, the data was prepared and organized for statistical analysis. In this research a visual statistical analysis was implemented to address the research question. The analysis procedure described trends in data. However, the researcher used descriptive analysis, such as measures of central tendency, the spread of the scores, the relative ranking of the scores, and the calculation of effect size that examines the strength of the differences and the practical meaning of these differences for group comparisons or relating variables. The results were presented in graphs and in a detailed discussion to address the research question. In order to address the confirmation bias, the researcher ensured that their prior beliefs would not influence on the study. This was done through a neutral data collection and analysis process and also by using inter-rater reliability. In the proposed study, two phases were conducted.

Table 7

Single Subject design applicability

Single Subject Design Applicability

Ages of participants: Useful for studying people of all ages.

Domain: Highly diverse domains, problem solving, attention, memory, theory of mind, scientific reasoning, mathematical reasoning, written language, motor activity, perception, and social development.

Setting: Applicable not only in laboratory settings but also in naturally occurring contexts and classrooms.

Theoretical underpinning: Useful for testing of all the major theories of cognitive development.

Siegler’s suggestions in Table 7 can be applied to students with MLD in general classrooms. Because his method is applicable to general students, it can be applied to students with MLD, as these students are included in the general classroom. The Single-Subject method is one of the most common designs employed in Microgenetic research works, as it provides a way to constantly monitor children’s performances (Siegler, 2006).

Single Subject design is capable of tracing the process of learning while it occurs. This method in particular has made possible an increasingly nuanced understanding of children’s learning, especially on an individualized level. The availability of such methods, together with other useful technologies, allow theorists to raise questions about the dynamics of development that otherwise would be impossible to answer, such as what happens immediately before a child makes a discovery and whether periods of transition are accompanied by especially high variability (Siegler, 2006).

AB Single-Subject design is one of the most common designs employed in Microgenetic research. An AB design is a two part or phase design composed of a baseline ("A" phase) with no changes, and a treatment or intervention ("B") phase. If there is a change then the treatment may be said to have had an effect. The major advantage of using this design is that there is no need for reversal. Moreover, it is fragile and emphasizes the need for series to be independent. As for the limitations in this kind of study is the small sample number which is also considered as strength point. Generalization in this kind of study is not appropriate. Furthermore, replication of the study can be considered.

CHAPTER FOUR

RESULTS

Context

The primary purpose of this study was to examine a largely-unexplored area method of teaching strategies such as the concrete representational abstract with map thinking teaching strategy for students with mathematical learning disabilities in Jordan. The second goal of this study is to examine similarities and differences in students' mathematical achievements.

The results are presented in three parts graphical form. First, baseline formation for each student is presented. Second, treatment and intervention phase for each student is reported. Third, follow-up phase and maintenance for each student is stated. Finally, I explained the functional relationship between the dependent variable, which is the students' proficiency in multiplication, and the independent variable which is the concrete representational abstract teaching strategy.

Graphic Analysis

The main form of analysis in single subject research is graphic analysis. In graphic analysis, you graph the data to see how it changes over time in both baseline and treatment conditions.

For each student, a graph was demonstrated. The graphic analysis process examined the interaction of multiple features such as; (a) Level, which is the mean of data points within a phase, (b) Trend, which shows the slope of best fit straight line (BL) for data within a phase, (c) Variability, which shows the range and standard deviation (SD) of data about the best fit straight line within a phase, (d) Overlap, which shows percent of data points in intervention phase that are within the range of data in best fit line, (e) Immediacy of effect, which shows change in level from last 3-5 data points in BL to first 3-5 data points in intervention, (f) Similarity of effect, which shows similar effects at point of intervention (introduction or withdrawal), and (g) Outliers, which are atypical data points.

Vertical and Horizontal Analysis

Vertical analysis shows that the change in one series is not associated with change in an uninterrupted series. However, it examines that dependent variable (DV) change in one series is associated with no change in other series. Moreover, it examines similar effects (consistent effect) across series. Horizontal analysis examines effect (per series) level, trend, variability, overlap, and immediacy of effect. For each student, means and standard deviations were calculated. A summary of the means and standard deviations for each student can be found in Table 8.

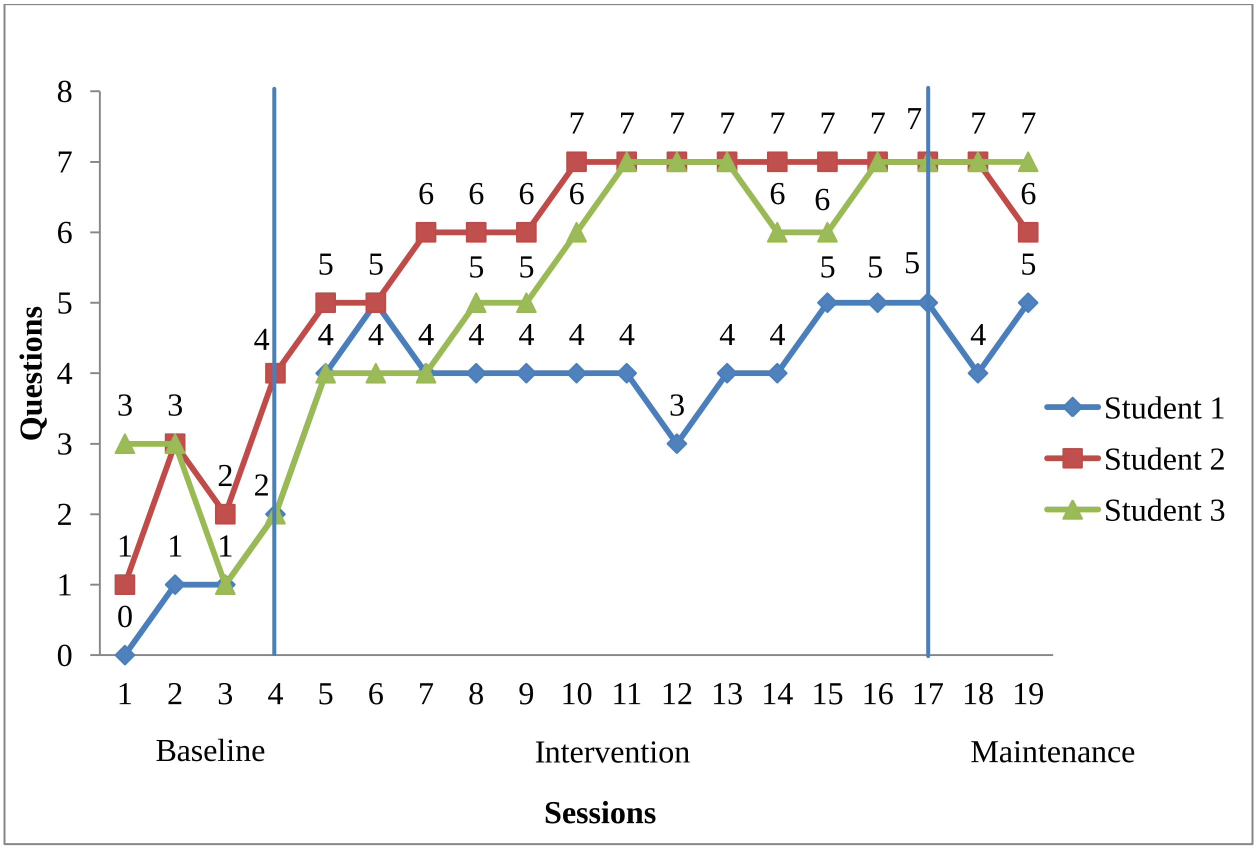


Figure 13. Base Line, Intervention, and follow up phases

Table 8

Mean, Median, Variance and Standard Deviation

Student	M	SD	Median	Variance
First student	4.7	0.77	4	0.59
Second Student	6.4	0.76	7	0.58
Third Student	5.7	1.19	6	1.42

Visual Inspection of Graphs

Within-Phase Patterns

The first dimension used in visual analysis is the level of the data. Level refers to the average of the data within a condition and is typically calculated as the mean or median. Figure 13 shows an intervention data set for the 1st student. There are 12 data points in the panel, with a mean of 4.7. Figure 13 shows an intervention data set for the 2nd student. There are 12 data points in the panel, with a mean of 6.4. Figure 13 shows an intervention data set for the 3rd student. There are 12 data points in the panel, with a mean of 5.7. Attending to the level of data within a phase allows for the estimation of the central tendency of the data during a particular part of an experiment. It also allows for comparison of patterns between phases. Although the absolute level within a phase is important, it should be noted, particularly in applied research, that the last few data points contain the most essential information regarding the level of performance before a phase change. The pattern of data shown in Figure 1, 2, and 3 illustrates this point. Although the mean level of the data is 4.7, the last few data points deviate from this level enough to warrant special emphasis.

A second dimension used to visually inspect graphs is the trend of the data. Trend refers to the best-fit straight line that can be placed over the data within a phase. Trend has two distinct elements that must be simultaneously evaluated: slope and magnitude. Slope is upward or downward slant or inclination of the data within a phase. Slopes are generally positive (upward), flat, or negative (downward). Figure 13 shows a positive slope in which the data points are increasing in value within a phase. The second element of a trend is magnitude, which is the size or extent of the slope. The magnitude of a trend is qualitatively estimated as high, medium, or low (much the same as a correlation or effect size statistic). Figure 13 shows medium – magnitude slope with a gradually increasing pattern in the data. The second method for quantitatively estimating trend is the split-middle technique (White, 1987).Using the split-middle technique requires seven or more data points within a phase and splits the data in half, establishes a median for each half, and then plots a line that intersects the two medians. A procedure for calculating the trend of a data set using the split-middle technique is presented in Table 9.

Table 9

How to Calculate a Split-Middle Trend Estimation Line

Count the number of data points in the phase that is being used for trend estimation.

Draw a line on the graph at the median data point to divide the graph into two halves.

Divide each of the halves in half using the technique described in step 2.

Identify the median of the data in each half of the split graph.

Mark the point at which the median number of sessions (x-axis) and median data level (y-axis) intersect for each half of the split graph.

Plot a straight line that intersects the two marks made in step 5.

Adjust the straight line plotted in step 6 so that 50% of the data points are above and below the line, making sure not to alter the slope of the line.

A third dimension used to judge within-phase data patterns is variability. Variability can be defined as the degree to which individual data points deviate from the overall trend. Or, stated another way, variability is the degree to which the data points are dispersed relative to the best-fit straight line. Like the magnitude of a trend line, the terminology used to refer to variability is largely qualitative. Variability is typically referred to as being high, medium, or low. Figure 13 shows medium variability.

Between-Phase Patterns

Along with level, trend, and variability within a phase, patterns occurring between phases are also used to visually inspect data. The first such pattern is referred to as immediacy of effect (or rapidity of change). This dimension of data display can be defined as how quickly a change in the data is produced after the phase change. This typically expressed as change in the level and trend of the data, although variability can also contribute to the change. Like slope and variability, qualitative descriptors, such as rapid or slow, are used to describe this aspect of data. If the intervention quickly alters the pattern of data it is called rapid immediacy of effect. On the other hand, if there is no initial change in the pattern of learning following introduction of the intervention, but then the data gradually increased over time. This pattern would be referred to as having a slow immediacy of effect. Figure 13 shows slow immediacy of effect.

A second between-phase pattern is referred to as overlap. Overlap can be defined as the percentage or degree to which data in adjacent phases share similar quantitative values. In Figure 13, there is no overlap (i.e., 0%) between baseline and intervention phases. This is because there are no overlapping data values between the two phases.

Additional Research Questions

The second primary purpose of this study was to examine the students with mathematical learning disabilities thinking and attitudes toward mathematics and their prediction of their own mathematics achievement. In order to understand the relationships among those variables, a number of qualitative questions were asked and analyzed. For the open-ended response questions the researcher interviewed three students with mathematical learning disabilities from Amman, Jordan. The researcher conducted the interviews and eight open-ended questions were used for coding responses such as “In your own words, please define what mathematics means to you.” First, the open-ended responses were coded for major themes. The researcher then independently recorded the responses with the clarified themes. Four themes or categories of open-ended responses were identified (i.e., difficulties, number organization, memorization, language skill levels). The researcher recorded the data via a variety of methods (interviews, observation, field notes, etc.), coding and categorizing (using a variety of clustering and classification schemes), attaching concepts to the categories, and writing an understanding.

The following examples of the three students’ responses from classroom observations, interviews, and notes demonstrate how students with mathematical learning disabilities used concrete representational abstract map thinking learning strategy and in addition to the VAKT learning method to solve multiplication problems.

First student's response: "It is hard to learn mathematics because it involves different sciences and different kind of numbers. Most difficult part is multiplication where I had to memorize the answers….because it is hard for me to learn multiplication…It is just too many numbers to memorize." Then the student shared "I use mathematics table and I add to help myself multiply. For example to solve 4x4 I say 4+4…. ohh no no I mean adding 4 times because you are doubling the four." The student said: "I learn that it keeps adding by the number when you are multiplying and the opposite number you are going up by..as 4x2=2+2+2+2." In addition "this works every time…but it will get harder. So I don't like doing that because numbers go bigger and bigger…if you get big numbers, you are unable to add that many numbers." As for when the student uses this method the answer was "I use this to help my word problems…and I use it in school to figure out different kind of work that I do with my friends…like when I do the work it confuses me and when I get multiplication in it…It is like the adding that I did before…this helped me work problems later in my mathematics multiplication."

Second student's response: "Mathematics was not hard in years before…they taught in a fun way…I didn't realize that it was hard …for example when I was a little kid they said a car plus a car equals….this was fun…when you are older you realize that it is just normal mathematics….use the things you learned in a subject like a type of mathematics +, -, ×, ÷." The student added "sometimes mathematics is hard because you get mixed up in the numbers…and sometimes if they are not organized in order…it will be harder?...I mean you have to put in straight order…and the most difficult part in multiplication is getting the answers correct." Moreover the students mentioned "It is basically addition because you are adding it once and twice so you are like doubling, tripling it and all that." As for using the adding strategy every time the student said: “I prefer finding a different way because it will take a long time...I use mathematics for money, for my homework and school…”

Third student’s response: “Mathematics is hard and it depends on what type it is….it takes time to get it in your head…you need to figure it out and remember it…I mean you need to know how to do it step by step.” The student added that the difficulties are in figuring out place value and numbers. The student mentioned: “adding and multiplying are the things to do in mathematics…you can use ways like 4+4 instead of 4x2…it depends which one is easier for you.” As for learning mathematics the student said: “you can use both skills to figure out your answer…yes, it will work but it will take you very long time.” The student indicated the importance of mathematics for people to figure out how much money they have…homework and…life….”

The previous interviews show how the open-ended questions results include various educational attitudes toward learning mathematics. See Table 10 for summary of subjects responses organized by themes.

Table 10

Subjects Responses Organized by Themes

	Themes			
Subjects	difficulties	number-organization	memorization	language skill
First Student	high	moderate	high	high
Second Student	high	low	moderate	high

Third Student	moderate	moderate	high	high

CHAPTER FIVE

DISCUSSION

Summary of Results

Researchers have indicated that for some time now students with mathematical learning disabilities perform poorly in mathematics compared to regular students. Mathematics is very important subject for general students' settings. However, few researchers have examined mathematical concepts and learning strategies with students with mathematical learning disabilities. The first goal of this study was to examine a largely unexplored area of teaching strategies for students with mathematical learning disabilities. Second, this study sought to find whether the concrete representational abstract multisensory teaching strategy would increase mathematical achievement in students with mathematical learning disabilities.

Based upon previous research, it was expected that various teaching strategies would have different impact on the teaching and learning mathematics; these different teaching methods would influence the mathematics that is taught and would enhance students 'learning (NCTM, 2000). In addition, teachers' attitudes play an important role in using various teaching strategies while teaching mathematics. It is very important to improve teachers' attitudes toward using a variety of teaching methods in the classroom because it enhances mathematics teaching and learning (Lin, 2008; Meo, 2008).

Relating to these expectations, it was found that there were no significant differences in previous research expectations and the results of the current study. The three students with mathematical learning disabilities showed significant improvement on mathematical multiplication evaluation after intervention period. They also showed retain of mathematical multiplication learning. The results of this study show the mean, median, standard deviation, (σ) and variance (σ^2). The "mean" is the "average", where you add up all the numbers and then divide by the number of numbers. The "median" is the "middle" value in the list of numbers. To find the median, your numbers have to be listed in numerical order, so you may have to rewrite your list first. The "mode" is the value that occurs most often. If no number is repeated, then there is no mode for the list. The "range" is just the difference between the largest and smallest values.

In this study the statistical results show that the median in the intervention phase for the second student is the highest 7, as for the 3rd student the median is 6. For the 1st student the median is the lowest which is 4. The mean for this study was 4.7 for the 1st student, 6.4 for the second student and 5.7 for the 3rd student.

The variance and the closely-related standard deviation are measures of how spread out a distribution is. In other words, they are measures of variability. The variance is computed as the average squared deviation of each number from its mean. In this study the variance for the 1st student is 0.59, for the 2nd student is 0.58, and for the 3rd student is 1.42. As for the standard deviation for the 1st student is 0.77, for the second student is 0.76, and for the 3rd student is 1.19. The formula to calculate the variance: is

$$\sigma^2 = \frac{\sum (X - \mu)^2}{N}$$

where μ is the mean and N is the number.

Calculating the variance is an important part of many statistical applications and analyses. It is the first step in calculating the standard deviation.

The standard deviation formula is very simple: it is the square root of the variance. It is the most commonly used measure of spread.

In the current study by using the standard deviation we have a "standard" way of knowing what is normal, and what is above normal or below normal. For example, the mean for the first student is 4.7 while the standard deviation is 0.77 by adding 4.7 + 0.77 the result will be 5.47 and by subtracting 4.7 - 0.77 the result will be 3.93 any data point above 5.47 or below 3.93 will be outlier.

However, the interview results assured the struggles students with mathematical learning difficulties face. The students described the mathematical concepts where they believe are difficult to comprehend. Therefore it is important to enhance mathematics instruction practices and the type of mathematics content students learn, and consider of how technology integration can address disability-related learning barriers in order to engage students with mathematical learning disabilities in active learning (Allosp, McHatton, and Farmer, 2010).

Discussion

Teaching is a learning inspiration, and a more detailed analysis reveals the understated and extensive effects of various instructional methods as it imposes on students' with mathematical learning disabilities: in the curriculum, in the organization and functioning of the classroom, and in the beliefs and attitudes about learning mathematics (Stigler & Perry, 1988). The decision to explore teaching strategies with students' with mathematical disabilities is not subjective. Research shows for some time now that mathematics is one of the most difficult components of the school curriculum for students with learning disabilities (NCES, 2008).

Various instructional practices will motivate students' interests and experience by engaging them in activities in which they will use numerous resources to explore a variety of problems and topics. Thus, the use of an RTI process as part of a school's procedures for determining whether a student has a MLD and needs special services can potentially reduce the time a student waits before receiving additional instructional assistance (Gersten and Dimino, 2006; Saddler Chambers, and Zeidler, 2004). In addition, reducing the overall number of students referred for special education services increases the number of students who succeed within general education. Moreover, it provides critical information about the instructional needs of the students, which can be used to create effective educational interventions (Fuchs, 2003; Mceneaney et al, 2006). Further, it limits the amount of unnecessary testing that has little or no instructional relevance (Gerber, 2005). Therefore, it ensures that students receive appropriate instruction, particularly in mathematics, prior to placement in special education (Murphy, Mazzocco, Hanich and Early, 2007).

Where should we look for clarification? The major concern we face is that significant number of students have low performance in mathematics despite well-equipped classrooms, new curriculum, and professional teachers (Hiebert, Morris, & Glass, 2003). However, while students in general are struggling, students with mathematical learning disabilities exhibit the most severe deficits (Fahsl, 2007; Maccini, Mulcahy, & Wilson, 2007). Although there are many interventions in mathematics for students with learning disabilities, there is still much to be done. A number of areas in the current mathematics curriculum should be addressed, and therefore, using multisensory teaching strategy will be recommended to help students with MLD to learn mathematics effectively in tomorrow's mathematics classrooms (Lin, 2008; Maccini et al 2007; Sood & Jitendra, 2007).

The focus of this study was to explore different teaching strategies among students with mathematical learning disabilities. In addition, the specific objectives of this study were: examining the concrete representational abstract teaching method as well as employing the multisensory teaching method in the instructional process. Various instructional practices will motivate students’ interests and experience by engaging them in activities in which they will use numerous resources to explore a variety of problems and topics. Thus, the use of the multisensory teaching strategy as part of a teaching procedure for students with mathematical disabilities provides instructional assistance and could be used to create effective educational intervention (Fuchs, 2003; Mceneaney et al, 2006). Further, it limits the amount of unnecessary testing that has little or no instructional relevance (Gerber, 2005). Therefore, it ensures that students receive appropriate instruction, particularly in mathematics, prior to placement in special education (Murphy, Mazzocco, Hanich and Early, 2007).

Several years ago Orton and Gillingham indicated the potential of multisensory approach in working with children with learning disabilities in reading. Within the area of mathematics the development of multisensory pedagogy underpinned by theory will enhance and develop students’ with mathematical disabilities, and possibly other learners’, mathematical abilities to achieve better, meaningful learning. Applying the multisensory method in teaching will help all students to use various learning pathways in the brain (visual, auditory, kinesthetic-tactile) simultaneously in order to enhance memory and learning. In general, multisensory approach includes techniques for linking the eye, ear, voice, and hand in a symbolic learning context. "Albert Einstein said, “Learning is experiencing. Everything else is just information” (Wesson, 2002, p.6). His insight suggests that we must experience our learning by using our complex sensory systems. Our species has an innate need to see, touch, taste, feel, and hear the features of any new object in order to understand it better," (Wesson, 2002). Thus, using senses for learning is an important natural learning tool.

First, auditory learners, or those with spoken language communication skills, according to Gardner’s Model of Multiple Intelligences, prefer to hear or read information. They look for clarifications with words. This learning style, which is related to hearing, dominates educational systems. According to Margulies and Sibbet (2009), 20% - 30% of people are auditory learners. Even though less than one-third of the population learns auditorily, this is the way most schools provide instruction. Auditory instruction involves direct teaching, recalling information in sequence, and teaching through reading. It is meaningful to note, "Although reading might seem, on the surface, to be a visual activity, research indicates that making sense of a string of syllables, words, sentences, and paragraphs is a left-brain (linear-sequential-analytical) function. Other types of information such as pictures, images, maps, charts, diagrams, and melodies are primarily processed in the part of the brain that specializes in perceiving patterns and integrating component parts into a recognizable whole," (Dalton & Farmer, 2002, p. 389). Since reading processing takes place in the language center of the brain, reading is an auditory activity, not a visual activity.

Visual learners, or those with visual / spatial learning style, according to Gardner's Model of Multiple Intelligences, favor graphs, diagrams, and pictures. They search for visual representations of knowledge. This learning style, which depends on the sense of sight and being able to visualize a mechanism, includes the skill to create internal mental images / pictures and enhancing this learning ability through visualization guided imagery and picturing exercises. According to Margulies & Sibbet (2009). visual learners represent 20% - 40% of the people. Visual learners have strong image – processing skills and prefer pictures for content learning. Visual learning content involves anything the learner sees and processes in the image center of the brain. It is essential to indicate, reading is not a visual learning activity (Dalton, Santanglo & Spence, 2009).

Kinesthetic learners, or those with body / movements learning abilities, according to Gardner's Model of Multiple Intelligences, are active learners. This learning style is connected to Physical experiments, learning by trying and the knowing / wisdom of the body. The brain's motor cortex controls physical motion by engaging the muscles in their bodies, by processing movements in their motor cortex, and by remembering the physical movements required to complete a task. "Kinesthetic learners need movement and action," (Maal, 2004). Thus, kinesthetic learners benefit from hands-on, manipulative activities, plays, moving around while memorizing, through re-enactments, art, dance, and other active learning channels. Maal says, "The kinesthetic modality is the farthest from language," and traditional teaching methods, therefore requires the most active, creative lesson planning.

The tactile learning style is almost always joined with the kinesthetic learning. Both styles involve bodily movement, and are very similar, but the tactile style is more moderate. It involves the sense of touch, and fine motor movements, rather than the large, whole-body movements seen in the kinesthetic learning style. The tactile learning style takes in information through the sense of touch and feeling, and generally has good eye-hand coordination. Students with a tactile learning style have active hands. They play with knobs and buttons, explore objects, examining and evaluating characters of objects. When in a class, persons with a tactile learning style may feel like they have to touch, and explore many objects to understand the characteristics of the object. Hand-on learning is the primary method for teaching tactile learners. Tactile learners enjoy manipulatives, using different media such as finger-paints, art materials, building projects, blocks or objects for math, hands-on science experiments, lap-booking (making their own books), games, making models, dioramas, etc.

Educational Implications

Results of the current study identify a number of emerging implications for educators, including the following:

1. Include effective teaching strategies to help students with mathematical learning disabilities acquire mathematical concepts and skills (Scarlato and Burr, 2002).
2. Include a graduated teaching structure into instruction to help students with mathematical learning disabilities advance to the abstract levels of mathematical understanding using the concrete, representational and abstract sequence (Maccini and Hughes, 2000; Witzel et al., 2003).
3. Use VAKT teaching strategy to improve the basic computation skills of middle and secondary students with mathematical learning disabilities (Calhoon and Fuchs, 2003).

Limitations

There are a number of limitations that one should consider before drawing final conclusions from this study. First, this study is limited by nature of the convenience sample. The number of participants is small due to the nature of single subject design that requires small number of subjects. Thus it may be limited in generalizability. However, replication in this kind of studies is acceptable.

In terms of Jordanian mathematically learning disabled students, the entire sample is from educated families in a capital city attending Al-Mashrek International School (see Appendix H). As a result of this context, students with learning disabilities achievement in terms of mathematics may be different than students from other urban or rural areas in Jordan. There is no variation in the subjects of this study; most of them are from the capital city, Amman, which is the biggest city in Jordan. The students generally speaking have high educational level as well as high socioeconomic status. In addition to these limitations, qualitative case studies are accused of lack of rigor. Yin (1984) noted that “too many times, the case study investigator has been sloppy, and has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions” (p.21). Second, case studies are often identified as being too long, difficult to conduct and producing a great amount of documentation (Yin, 1984). In particular, the danger comes when the data are not managed and organized systematically. A common criticism of case study method is its dependency on a single case examination making it difficult to reach a generalizing conclusion (Tellis, 1997). Yin (1994) considered case methodology “microscopic” because of the limited sampling cases. To Yin (1994), however, parameter establishment and objective setting of the research are far more important in case study method than a big sample size.

Future Directions

We may have learned several new directions for research from this study. Still, a number of areas for future research should be addressed. First, there is a need for stronger research designs and research reporting within the field of mathematics interventions for middle and secondary students with mathematical learning disabilities. Researchers need to include valid assessments, as well as thorough descriptions of the subjects and the intervention in order to replicate research. In terms of nature and focus of interventions, future research should also address middle school or high school curriculum standards. There is also need to continue to advance knowledge of the instructional design variables that positively affect students learning in mathematics. Finally, research might expand on VAKT teaching strategy by targeting students with special needs to enhance mathematics concepts and skills.

Mathematics is important for daily living necessities that require skills such as budgeting, time management, and cooking, as well as for educational and occupational opportunities that reflect an increasingly technological society that requires problem solving and reasoning abilities (Maccini, Mulcahy, and Wilson, 2007). Because 5-8 percent of school-aged students experience some sort of mathematical learning disabilities (Geary, 2004), it is essential to identify instructional practices that are effective and suitable for helping students with mathematical learning disabilities succeed both in and out of school (Maccini, Mulcahy, and Wilson, 2007).

Conclusions

Generally speaking, findings from this study support the notion that various teaching methods and strategies provide an effective integration within mathematics for helping students with mathematical learning disabilities. The research provided a summary of the context surrounding mathematics highlighting the VAKT map thinking teaching method. The study also described a framework for systematic integration of VAKT map thinking teaching strategy that attends to several areas that are important for students with mathematical learning disabilities.

Essentially, the findings of this study should remind researchers, practitioners, teachers, and parents who work with students with mathematical learning disabilities to be aware of the characteristics of learning disabled students that require specific teaching methods and strategies. This understanding will allow these individuals to be more considerate to the specific needs of these students and help them develop successfully their mathematical skills. As one of the most important responsibilities of education, is to help students work toward their maximum intellectual development.

References

Abedi, J., & Dietel, R. (2004). Challenges in the no child left behind act for English-language learners. *Phi Delta Kappan, 85*, 782-785.

Aldridge, J. (2008). Among the periodicals: What's happening in special education?. *Childhood Education, 84*(3), 180-182.

Algebra (2011). What is Algebra? Retrieved April, 28, 2011 from: http://cstl.syr.edu/fipse/algebra/unit1/algebra.htm

Algozzine, B., & Ysseldyke, J. (1992). *Strategies and tactics for effective instruction*. Sopris West, 1140 Boston Ave., Longmont, CO 80501.

Al-Hroub, A. (2010). Mathematics education and the gifted: Programming for mathematically gifted children with learning difficulties. *Roeper Review 32.* 259-271.

Allosp, D. H., Kyger, M. M., lovin, L., Gerretson, H., Carson, K. L., Ray, S. (2008). Mathematics Dynamic Assessment: Informal assessment that responds to the needs of struggling learners in mathematics. *Teaching Exceptional Children, 40*(3), 6-16.

Allsopp, D. H., McHatton, P., & Farmer, J. L. (2010). Technology, mathematics PS/RTI, and students with LD: What do we know, what have we tried, and what can we do to improve outcomes now and in the future? *Learning Disability Quarterly, 33*(4), 273-288.

Babbitt, B. C., & Miller, S. P. (1996). Using hypermedia to improve the mathematics problem-solving skills of students with learning disabilities. *Journal of Learning Disabilities, 29*(4), 391-401.

Baker, E. T., Wang, M., & Walberg, H. J. (1995). The effects of inclusion on learning.

Educational Leadership, December/January, 33-35.

Badian, N. (1999). Persistent mathematics, reading or mathematics, or reading disability. *Annals of Dyslexia, 49,* 45-70.

Beck, J., (2002). Emerging literacy through assistive technology. *Teaching Exceptional Children, 35*(2), 44-48.

Behrend, J. (2003). Learning disabled students make sense of mathematics. *Teaching Children Mathematics 9*(5), 269-273.

Bishop, J., Stump, S., & Britton, B. (2003). Building a vision of algebra for preservice teachers. *Teaching children mathematics, 10*(3), 180-186.

Bley, N. S., & Thornton, C. A. (2001). *Teaching mathematics to students with learning disabilities*. PRO-ED, Inc., 8700 Shoal Creek Blvd., Austin, TX 48757-6897.

Bottge, B. A., Heinrichs, M., Chan, S., Mehta, Z. D., & Watson, E. (2003). Effects of video-based and applied problems on the procedural math skills of average-and low-achieving adolescents. *Journal of Special Education Technology, 18*(2), 5-22.

Browder, D. M., Spooner, F., Ahlgrim-Delzell, L., Harris, A.A., Wakeman, S. (2008). A meta-analysis on teaching mathematics to students with significant cognitive disabilities. *Exceptional Children, 74*(4), 407-432.

Brown-Chidsey, R., & Steege, M. W. (2005). *Response to intervention: Principles and Strategies for effective practice.* The Guilford Press: New York.

Burn, M.K. (2005). Using incremental rehearsal to increase fluency of single-digit multiplication facts with children identified as learning disabled in mathematics computation. *Education and Treatment of Children, 28*(3), 237-249.

Calhoon, M., & Fuchs, L. S. (2003). The effects of peer-assisted learning strategies and curriculum-based measurement on the mathematics performance of secondary students with disabilities. *Remedial and Special Education, 24*(4), *235-245.*

Calvin Gagnon, J., & Maccini, P. (2007). Teacher-reported use of empirically validated and standards-based instructional approaches in secondary mathematics. *Remedial & Special Education*, *28*(1), 43.

Catts, R., & Lau, J. UNESCO. 2008. Towards information literacy indicators. Conceptual framework paper with a list of potential international indicators for information supply, access and supporting skills by UNESCO Institute for Statistics.

Cawley, J., Parmar, R., Foley, T.E., Salmon, S., & Roy, S. (2001). Arithmetic performance of students: Implications for standards and programming. *Exceptional Children, 67*, 311-328.

Cirino, P. T., Fletcher, J., M. (2007). Cognitive arithmetic differences in learning difficulty groups and the role of behavioral inattention. *Learning Disabilities Research & Practice, 22*(1), 25-35.

Colony, B. (2001). History of Orton-based multisensory structured language methods. In C. W. McIntyre and J. S. Pickering (Eds.), *Clinical studies of multisensory structured language education for students with dyslexia and related disorders,* (pp16-19). International Multisensory Structured Language Education Council: Dallas, TX.

Creswell, J. W. (2008). *Educational research: Planning, conducting and evaluating quantitative and qualitative research.* Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Dalton, P., Santangelo, V., & Spence, C. (2009). The role of working memory in auditory selective attention. *The Quarterly Journal of Experimental Psychology*, *62*(11), 2126-2132.

Daly, E.J. & McCurdy, M. (2002). Getting it right so they can get it right: An overview of the special series. *School Psychology Review, 37,* 453-458.

Dugan, L.M., Campbell, P.H., Wilcox, M.J., (2006). Making decisions about assistive technology with infants and toddlers. *Topics in Early Childhood Special Education, 26*(1), 25-32.

Evans, D. (2007). Developing mathematical proficiency in the Australian context: Implications for students with learning difficulties. *Journal of Learning Disabilities, 40*(5), 420-426.

Ellis, E.S. & Sabornie, E.J. (1990). Strategy-based adaptive instruction in content-area classes: Social validity of six options. *Teacher Education and Special Education, 13*(2), 133-144.

Epstein, J. L., & Sheldon, S. B. (2002). Present and accounted for: Improving student attendance through family and community involvement. *The Journal of Educational Research*, ` *95*(5), 308-318.

Fahsl, A. J (2007). Mathematics accommodations for all students. *Intervention In School And Clinic, 42*(4), 198-203.

Fingerithmatic: Multi-sensory mathematics. Retrieved March 16, 2011 from http://www.fingerithmatic.com/

Foegen, A. (2008). Algebra progress monitoring and interventions for students with learning disabilities. *Learning Disability Quarterly*, *31*(2), 65-78.

Fuchs, D., Mock, D., Morgan, P. L., & Young, C.L. (2003). Responsiveness-to- Intervention: Definitions, evidence, and implications for the learning disabilities construct. *Learning Disabilities Research & Practice, 18*(3), 157-171.

Fuchs, L. S. (2003). Assessing intervention responsiveness: Conceptual and technical issues. *Learning Disabilities Research & Practice, 18*(3), 172-186.

Fuchs, L. S., Compton, D. L., Fuchs, D., Paulsen, K., Bryant, J., & Hamlett, C. L. (2005). Responsiveness to Intervention: Preventing and identifying mathematics disability. *Teaching Exceptional Children*, *37*(4), 60-63.

Fuchs, L.S., Fuchs, D., Hollenbeck, K. N., (Feb 2007). Extending responsiveness to intervention to mathematics at first and third grades. *Learning Disabilities Research and Practice 22*(1), 13-24.

Fuchs, L.S., Seethaler, P.M., Powell, S. R., Fuchs, D., Hamlett, C. L.,Fletcher, J. M. (2008). Effects of preventative tutoring on the mathematical problem solving of third-grade students with math and reading difficulties. *Exceptional Children, 74*(2), 155-173.

Funkhouser, C. (1995). Developing number sense and basic computational skills in students with special needs. *School Science and Mathematics 95*(5), 236-239.

Garderen, D.V. (Nov / Dec 2007). Teaching students with LD to use diagrams to solve mathematical word problems. *Journal of Learning Disabilities, 40*(6), 540-553.

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities, 37*(1), 4-15.

Geiger, W. L., Crutchfield, M. D., & Mainzer, R. (2003). The status of licensure of special education teachers in the 21st century. *Center on Personnel Studies in Special Education.(COPSSE document no. RS-7). Retrieved November*, *10*, 2008.

Gerber, M. M. (2005). Teachers are still the test limitations of response to instruction strategies for identifying children with learning disabilities. *Journal of Learning Disabilities, 38*(6), 516-524.

Gersten, R., & Dimino, J. A. (2006). RTI (response to intervention): Rethinking special education for students with reading difficulties (yet again). *Reading Research Quarterly, 41*(1), 99-108.

Gersten, R., Jordan, N. C., (Jul/Aug 2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities, 38*(4), 1-12.

Giess, S. (2005). *Effectiveness of a Multisensory, Orton-Gillingham Influenced Approach to Reading Intervention for High School Students with Reading Disability* (Doctoral dissertation, University of Florida).

Gillingham, A., & Stillman, B.W. (1997). *The Gillingham manual. Remedial training for students with specific disability in reading, spelling, and penmanship.* Cambridge, MA: Educators Publishing Service, Inc.

Griffin, H., Williams, S., Davis, M., Engleman, M., (2002). Using technology to enhance cues for children with low vision. *Teaching Exceptional Children, 35*(2), 36-42.

Hardy, M., (2008). It's time for technology: The technology in mathematics education project. *JI. Of Computers in Mathematics and Science Teaching, 27*(2), 221-237.

Herbel-Eisenmann, B., & Breyfogle, M. L. (2005). Questioning our patterns of questioning. *Mathematics Teaching in the Middle School, 10*(9), 484-489.

Hiebert, J., Morris, A. K., & Glass, B. (2003). Learning to learn to teach: An "experiment" model for teaching and teacher preparation in mathematics.

Journal of Mathematics Teacher Education 6, 201-222.

H.K.J Ministry of Education (MOE). (2004), *The Development of Education: National report of the Hashemite Kingdom of Jordan: presented to the 47th session of the International Conference on Education Geneva (8-11 September 2004)*. Geneva. Government report. www.ibe.unesco.org/international/databanks/dossiers/Jordan.

H.K.J Ministry of Higher Education (MOHE). (2005), *Ministry of Higher Education: general statistics*. Amman. Government reports http://www.MOHE.gov.jo/statistics/default/asp.

Howland, A., Anderson, J. A., Smiley, A. D., & Abbott, D. J. (2006). School liaisons: Bridging the gap between home and school. *School Community Journal*, *16*(2), 47.

Impecoven-Lind, L. S., & Foegen, A. (2010). Teaching algebra to students with learning disabilities. *Intervention in School and Clinic*, *46*(1), 31-37.

Individuals with Disabilities Education Improvement Act of 2004, 20 U.S.C. 614 *et seq*

Jabery, M., Zumberg, M. (2008). General and special education systems in Jordan: Present and future perspectives. *International Journal of Special Education, 23*(1), 115-122.

Jitendra, A. K., Hoff, K., & Beck, M. M. (1999). Teaching middle school students with learning disabilities to solve word problems using a schema-based approach. *Remedial and Special Education, 20*(1), 50-64.

Kauffman, J. M. (2007). Conceptual models and the future of special education. *Education and Treatment of Children, 30*(4), 241-258.

Kavale, K. A., & Forness, S. R. (2000). What definitions of learning disability say and don't say a critical analysis. *Journal of learning disabilities*, *33*(3), 239-256.

Ketterlin-Geller, L. R., Chard, D. J., & Fien, H. (2008). Making connections in mathematics conceptual mathematics intervention for low-performing students. *Remedial and*

Special Education, 29(1), 33-45.

Kilpatrick, J. (2009). The mathematics teacher and curriculum change. *PNA*, *3*, 3.

Kluwin, T. N., & Kelly, A. B. (1992). Implementing a successful writing program in public schools for students who are deaf. *Exceptional children*, *59*(1), 41-53.

Kozma, R. B. (1991). Learning with media. *Review of educational research, 61*(2), 179-211.

Kroesbergen, E. H., & Van Luit, J. E. H. (2003). Mathematics interventions for children with special educational needs: A Meta-Analysis. *Remedial and Special Education 24*(2), 97-114.

Kunsch, C. A., Jitendra, A. K., Sood, S., (Feb 2007). The effects of peer-mediated instruction in mathematics for students with learning problems: A research synthesis. *Learning Disabilities Research and Practice, 22*(1), 1-12.

Lerner, J. (2003). Learning disabilities: Theories, diagnosis, and teaching strategies (9th ed.). Boston: Houghton Mifflin.

Lamon, S. J. (2006). *Teaching Fractions And Ratios For Understanding.* Lawrence Erlbaum Associates, Publishers: Mahwah, New Jersey.

Laurienti, P., Burdette, J., H. Maldjian, J. A., and Wallace, M. T. (2006). Enhanced multisensory integration in older adults. *Neurobiology of Aging 27*. 1155-1163. Doi: 10.1016/j.neurobiolaging.2005.05.024.

Light, G.J., & DeFries, J. C. (1995). Comorbidity for reading and mathematics disabilities: Genetic and environmental etiologies. *Journal of Learning Disabilities, 28,* 96-106.

Lin, C., (2008). Preservice teachers' beliefs about using technology in the mathematics classroom. *JI. Of Computers in Mathematics and Science*

Teaching, 27(3), 341-360.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States.* Mahwah, NJ: Lawrence Erlbaum.

Maccini, P., & Gagnon, J. C. (2000). Best practices for teaching mathematics to secondary students with special needs. *Focus on Exceptional Children, 32*, 1-22.

Maccini, P., & Hughes, C. A. (2000). Effects of a problem-solving strategy on the introductory algebra performance of secondary students with learning disabilities. *Learning Disabilities Research and Practice, 15*(1), 10-21.

Maccini, P., & Gagnon, J. C. (2006). Mathematics instructional practices and assessment accommodations by secondary special and general educators. *Exceptional Children 72*(2), 217-234.

Maccini, P., Mulcahy, C.A., & Wilson, M.G. (2007). A follow-up of mathematics interventions for secondary students with learning disabilities. *Learning Disabilities Research and Practice*, *22*(1), 32-33.

Manzo, K. K., & Galley, M. (2003). Math climbs, reading flat on '03 NAEP. Education Week, 23 (12), 1, 18.

Marchand, A. (2010). 2-year colleges help learning-disabled students break into math and science. *Chronicle of Higher Education*, *56*(26), A25.

Margulies, N., & Sibbet, D. (2009). Visual recording and graphic facilitation: Helping people see what they mean. *The Change Handbook: The Definitive Resource on Today's Best Methods for Engaging Whole Systems: Easyread Super Large 24pt Edition*, 366.

Marston, D. (Nov / Dec 2005). Tiers of intervention in Responsiveness to Intervention:

Prevention outcomes and learning disabilities identification patterns. *Journal of Learning Disabilities, 38*(6), 539-544.

Mattingly, D. J., Prislin, R., McKenzie, T. L., Rodriguez, J. L., & Kayzar, B. (2002). Evaluating evaluations: The case of parent involvement programs. *Review of Educational Research, 72*(4), 549-576.

Mceneaney, J.E., Lose, M. K., Schwartz, R. M. (Jan / Feb / Mar 2006). A transactional perspective on reading difficulties and Response to Intervention. *Reading Research Quarterly, 41*(1), 117-128.

Meo, G., (2008). Curriculum planning for all learners: Applying universal design for learning (UDL) to a high school reading comprehension program. *Preventing School Failure, 52*(2), 21-30.

Mercer, C. D., Jordan, L., & Miller, S. P. (1994). Implications of constructivism for teaching math to students with moderate to mild disabilities. *Journal of Special Education, 28,* 290-306.

Miller, S. P. (2007). Using evidence-based practices to build mathematics competence related to conceptual, procedural, and declarative knowledge. *Learning Disabilities Research and Practice, 22*(1), 47-57.

Miller, S., Butler, F. M., & Lee, K. (1998). Validated practices for teaching mathematics to students with learning disabilities: A review of literature. *Focus on Exceptional Children, 31*(1), 1.

Miller, S., & Mercer, C. (1997). Educational aspects of mathematics disabilities. *Journal of Learning Disabilities, 30*(1), 47-56.

Montague, M. (2007). Self-regulated and mathematics instruction. *Learning Disabilities Research and Practice*, *22*(1), 75-83.

Moscardini, L. (209). Tools or crutches? Apparatus as a sense-making aid in mathematics teaching with children with moderate learning difficulties. *Support for Learning*, *24*(1), 35-41.

Multisensory Teaching Methods. Retrieved March 16, 2011 from http://www.scribd.com/doc/920278/Multisensory-Teaching-Methods

Murphy, M. M., Mazzocco, M. M., Hanich, L. B., & Early, M. C. (2007). Cognitive characteristics of children with mathematics learning disability (MLD) vary as a function of the cutoff criterion used to define MLD. *Journal of Learning Disabilities*, *40*(5), 458-478.

Naglieri, J. A., & Johnson, D. (2000). Effectiveness of a cognitive strategy intervention in improving arithmetic computation based on the PASS theory. *Journal of Learning Disabilities, 33*(6), 591-597.

National Center for Educational Statistics (2008). Mathematics: *The Nation's Report Card. Retrieved December, 1, 2009* from: http://nces.ed.gov/nationsreportcard/mathematics

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

No Child Left Behind Act of 2001, 20 U.S.C 6301 *et seq.*

Nurnberger-Haag, J. (2003). Order of Op Hop. *Mathematics Teaching in the Middle School 8*(5). 234-236.

Ofiesh, N. (2006). Response to Intervention and the identification of specific learning disabilities: Why we need comprehensive evaluations as part of the process. *Psychology in the Schools, 43*(8), 883-888.

Ojose, B. (2009). Promising practice of technology integration in math and science instruction: A case of California Charter High School. *International Education Studies 2*(3), 3-17.

Ozaki, C., Williams, R. L., & McLaughlin, T. F. (1996). Effects of a copy/cover/compare drill and practice procedure for multiplication facts mastery with sixth grade student with learning disabilities. *B. C. Journal of Special Education, 20*(2), 65-74.

Paige, R. (2002). Meeting the highly qualified teachers challenge: The Secretary's Annual Report on Teacher Quality. *US Department of Education*.

Park, Y., & Chae, H. T. (2005). The Effects of Inclusion on the Self-Esteem of Students with Learning Disabilities.

Puckett, K., S. (2004). Project ACCESS: Field testing an assistive technology toolkit for students with mild disabilities. *Jornal of Special Education Technology, 19(2)*, 5-17.

Rivera-Batiz, F. L. (1992). Quantitative literacy and the likelihood of employment among young adults in the United States. *Journal of Human Resources*, 313-328.

Rose, D. E., Meyer, A., & Hitchcock, C. (2006). *The universally designed classroom: Accessible curriculum and digital technologies.* Cambridge, MA: Harvard Education Press.

Sadler, T. D., Chambers, F. W., & Zeidler, D. L. (2004). Student conceptualizations of the nature of science in response to a socioscientific issue. *International Journal of Science Education, 26*(4), 387-409.

Santangelo, V., & Spence, C. (2007). Multisensory cues capture spatial attention regardless of perceptual load. *Journal of Experimental Psychology: Human Perception and Performance,33*(6), 1311.

Scarlato, M. C., & Burr, W. A. (2002). Teaching fractions to middle school students. *Journal of Diorect Instruction, 2*(1), 23-38.

Scheuermann, A. M., Deshler, D. D., & Schumaker, J. B. (2009). The effects of the explicit inquiry routine on the performance of students with learning disabilities on one-variable equations. *Learning Disability Quarterly*, *32*(2), 103-120.

Shams, L. and Seitz, A. R. (2008). Benefits of multisensory learning. *Trends in Cognitive Sciences*, 1-7.

Siegler, R. S. (2006). Microgenetic Analysis of Learning. In D. kuhn, & R. S. SIEGLER (Eds.), *Handbook of child psychology (6th ed.)*(pp. 464-510). Hoboken, NJ: John Wily & Sons, Inc.

Simon, R., & Hanrahan, J. (2004). An evaluation of the Touch Math method for teaching addition to students with learning disabilities in mathematics. *European journal of special needs education*, *19*(2), 191-209.

Sood, S., Jitendra, A.K. (2007). A comparative analysis of number sense instruction in reform-based and traditional mathematics textbooks. *The Journal of Special Education*, *41*(3), 145-157.

Spooner, F., Baker, J.N., Harris, A. A., Ahlgram-Delzell, L., Browder, D.M. (2007). Effects of training in universal design for learning on lesson plan development. *Remedial and Special Education, 28*(2), 108-116.

Stahl, S & Aronica, M. (2002). *Digital Text in the Classroom*. Journal of Special Education Technology*17*(2). (Retrieved October 5, 2009 from:

http://jset.unlv.edu/17.2T/tasseds/rose.html)

Steelman, J. (1947). Manpower for research. Washington, DC: Government Printing Office.

Stevenson, D. L., & Baker, D. P. (1987). The family-school relation and the child's school performance. *Child development*, 1348-1357.

Stigler, J. W., & Hiebert, J. (2004). Improving mathematics teaching. *Educational leadership, 61*(5), 12-17.

Stigler, J. W., & Perry, M. (1988). Mathematics learning in Japanese, Chinese, and American classrooms. *New Directions for Child and Adolescent Development*, *1988*(41), 27-54.

Susan Lamon (2006). *Teaching Fractions and Ratios for Understanding.* Second Edition. Mahwah, NJ: Lawrence Erlbaum.

Tellis, Winston, (1997). Introduction to case study. *The Qualitative Report*, *3*(2). from http://www.nova.edu/ssss/QR/QR3-2/tellis1.html.

Test, D. W., & Ellis, M. F. (2005). The effects of LAP fractions on addition and subtraction of fractions with students with mild disabilities. *Education and Treatment of Children, 28*(1), 11-24.

U.S. Department of Education (2007). *National assessment of educational progress. The nation's report card.*Washington, D.C.: Institute of Education Sciences (NCES 2004-451/452).

Usher, A. (2011). AYP Results for 2010-11. *Center on Education Policy*.

Van der Kolk, B. A. (2006). Clinical implications of neuroscience research in PTSD. *Annals of the new York Academy of Sciences*, *1071*(1), 277-293.

Vaughn, S., Gersten, R., & Chard, D. J. (2000). The underlying message in LD intervention research: Findings from research syntheses. *Exceptional Children, 67*(1), 99-114.

Weiss, I. R., Heck, D. J., & Shimkus, E. S. (2004). Looking inside the classroom: Mathematics teaching in the United States. *NCSM Journal of Mathematics*.

Wesson, Ken (August 2002). What Everyone Should Know About the Latest Brain Research. from http://www.sciencemaster.com/columns/archives/wesson_2000.php

White, O. R. (1987). Some comments concerning "The quantitative synthesis of single-subject research". *Remedial and Special Education, 8*(2), 34-39.

White, J. D., & Gerson, H. H. (2005). Pre-service teachers use of technology as a pseudo-collaborator in an open-response, task-based environment. *Technology, 2*, 871.

Wildmon, M. E., Skinner, C. H., Watson, T. S., & Garett, L. S. (2004). Enhancing assignment perceptions in students with mathematics learning disabilities by including more work: An extension of interspersal research. *School Psychology Quarterly, 19*(2), 106-120.

Witzel, B. S. (2005). Using CRA to teach algebra to students with math difficulties in inclusive setting. *Learning Disabilities: A Contemporary Journal, 3*(2), 53-64.

Witzel, B. S., Mercer, C. D., & Miller, M. D. (2003). Teaching algebra to students with learning difficulties: An investigation of an explicit instruction model. *Learning Disabilities Research and Practice, 18,* 121-131.

Witzel, B. S., Smith, S. W., & Brownell, B. T. (2001). How can I help students with learning disabilities in algebra? *Intervention in School and Clinic, 37*, 101-104.

Yin, R.K., (1984). *Case Study Research: Design and Methods*. Beverly Hills, Calif: Sage Publications.

Yin, R., (1994). *Case study research: Design and methods* (2nd ed.). Beverly Hills, CA: Sage

Publishing.

Appendix A

Research Participants Consent Form

Teaching Mathematics: Serving Students with Learning Disabilities
Washington State University
Department of Teaching & Learning

Researcher: Ani Derderian, Ph.D student in the Department of Teaching & Learning, 509-335-6842, Email: aderderian@wsu.edu

Purpose of the study: This study is designed to examine a largely-unexplored area of teaching strategies such as the concrete representational abstract for students with mathematical learning disabilities.

Procedure: Your principle has given permission for this study. Students with learning disabilities are invited to participate in this study. If you and your child agree to participate, your child will be asked to be part of this study. Students need to complete the instructional period, complete daily based tests and bring the signed consent form and the assent form to their classroom teachers. The instruction will be on numerical concepts and the test questions will be on multiplication and division facts to 12.

Benefits: The information gathered in this study will help students with mathematical learning disabilities; teachers and researchers better understand mathematics.

Risks: There are few risks to you or your child if you agree to participate in this study. If any of the test questions make you uncomfortable, you may choose not to answer that question.

Voluntary nature of participation: Your participation in this study is entirely voluntary. You may decide at any point in time to stop participating without penalty.

Confidentiality: All information we collect from you will be kept strictly confidential. You will be assigned an ID number and your answers will be entered into a data file that contains only your ID number, not your name. In all reported results, your child's identity will remain anonymous.

CONSENT STTEMENT:

This study has been explained to me and my child. My child and I volunteer to take part in this research. I have had a chance to ask questions. If I have general questions about the research, I can ask the researchers listed above. If I have questions regarding my rights as a participant, I can call the WSU Institutional Review Board at (509)335-9661. This project has been reviewed and approved for human participation by the WSU IRB. I will receive a copy of this consent form.

________________________	________________________	______________
Participant's Parent Signature	Full Name (please print)	Date

Appendix B

Research Participants Assent Form

Teaching Mathematics: Serving Students with Learning Disabilities
Washington State University
Department of Teaching & Learning

Researcher: Ani Derderian, Ph.D student in the Department of Teaching & Learning, 509-335-6842, Email: aderderian@wsu.edu

We are doing a research study about teaching mathematics: serving students with learning disabilities. A research study is a way to learn more about instructional methods to help students. If you decide that you want to be part of this study, you will be asked to complete instructional period of 4 weeks, 45 minute each day.

Your principle has given permission for this study. Elementary school students are invited to participate in this study. If you agree to participate, you will be asked to attend instruction and complete tests. You need to do tests, bring the signed consent form and the signed assent form to your classroom teacher. The instruction will be on numerical concepts and the test questions will ask you about multiplication and division facts to 12.

The information gathered in this study will help students with mathematical learning disabilities; teachers and researchers better understand mathematical instruction strategies. With this information, researchers may have a better picture about students' mathematics teaching and learning.

When we are finished with this study we will write a report about what was learned. This report will not include your name or that you were in the study.

You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too.

This study has been reviewed and approved by the WSU Institutional Review Board (IRB). If you have questions about this study, please contact the researcher at 509-335-7652. If you have questions about your rights as a participant, please contact the WSU IRB at 509-335-9661.

If you decide you want to be in this study, please sign your name.
I, ___________________________________, want to be in this research study.
(Print your name here)

_____________________________________ _______________
(Sign your name here) (Date)

Appendix C

Pre-Test
Teaching Mathematics: Serving Students with Learning Disabilities
Washington State University
Department of Teaching & Learning

The purpose of this test is to assess mathematical numerical understanding over a five-day period to determine a baseline level of mathematical ability. It will take about 15-30 minutes to complete the test. If your parents and you agree to participate in this study, please sign the consent form and assent form. Please return the completed test and signed forms to your classroom teacher. Thanks for your participation!

Background Information

School Name ________________________

Which grade are you in? ___________________________

Gender? ☐ **Male** ☐ **Female**

What is your Ethnicity? ☐ **Jordanian**

☐ **Other**

What is your parents' highest level of education?

☐ **Some High School** ☐ **High School**

☐ **Some College** ☐ **College Degree**

☐ **Graduate/Professional (e.g. MA, Ph.D)**

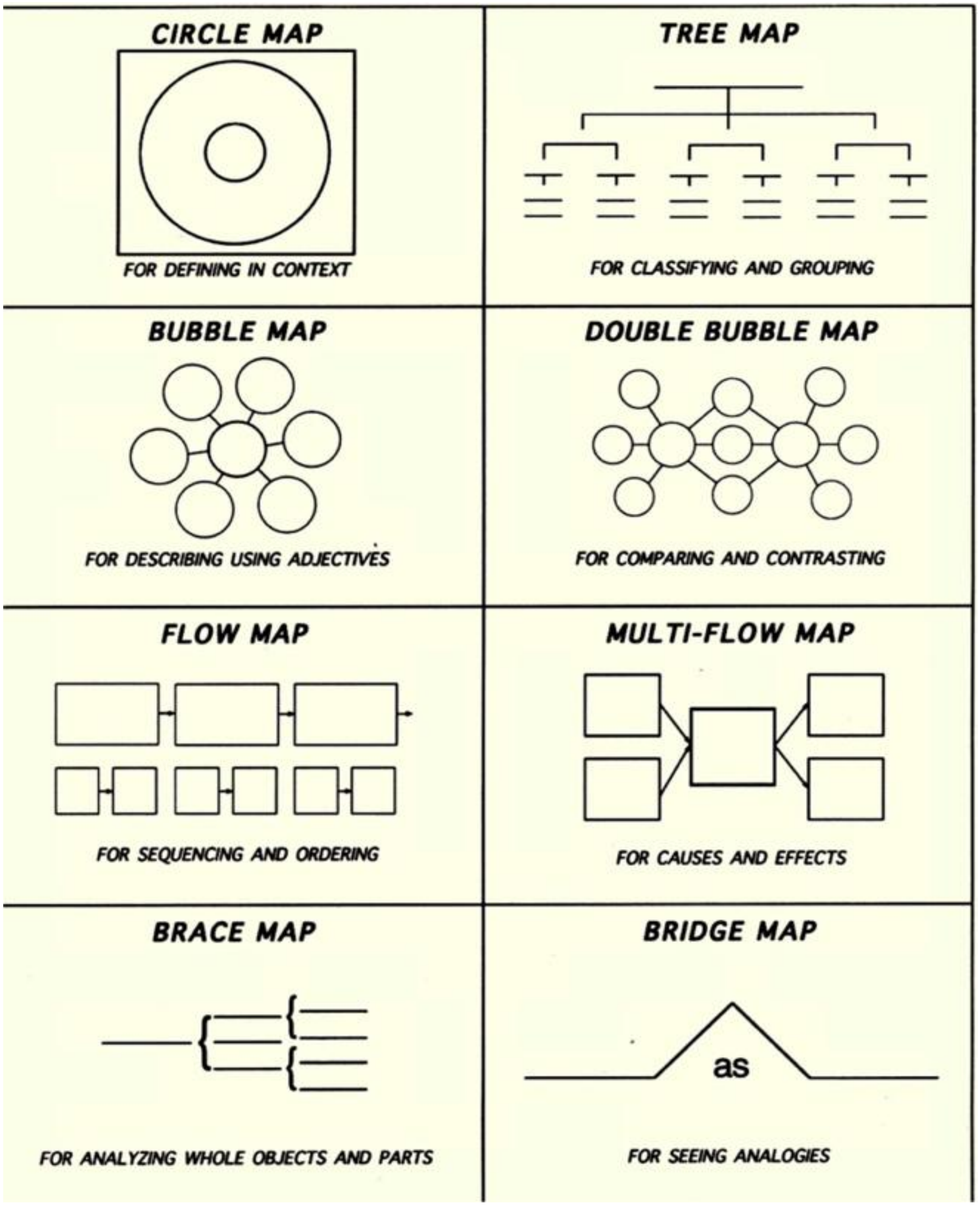
Other (please specify) _____________________

Please answer the questions in the designed box ☐

First Session:	**Second Session:**	**Third Session:**	**Fourth Session:**
3 x 4 = □	3 ÷ 1 = □	8 ÷ 4 = □	10 ÷ □= 2
12 ÷ 4 = □	3 ÷ 3 = □	8 ÷ 2 = □	3 ÷ □= 3
12 ÷ 3 = □	20 ÷ 4 = □	12 ÷ 4 = □	3 ÷ □ = 1
15 ÷ 3 = □	20 ÷ □ = 4	10 ÷ 2 = □	5 ÷ 1 = □
15 ÷ 5 = □	5 x □ = 10	2 x 5 = □	6 x 1 = □
1 x 3 = □	3 x □= 3	6 x 2 = □	6 x □ = 6
4x 2= □	5 x 3= □	3 x 2 = □	3 x □ = 6
□x 4 = 20	5 x □ = 10	2 x 5 = □	□x 5 = 5

Appendix D

Concrete Representational Abstract (Thinking Maps)
Teaching Mathematics: Serving Students with Learning Disabilities
Washington State University
Department of Teaching & Learning

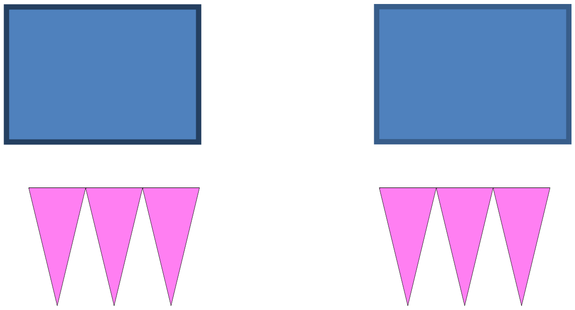


Adopted from: Visual Tools that Work, www.thinkingmaps.com

Examples of Concrete Representational Abstract (Map Thinking) strategy:

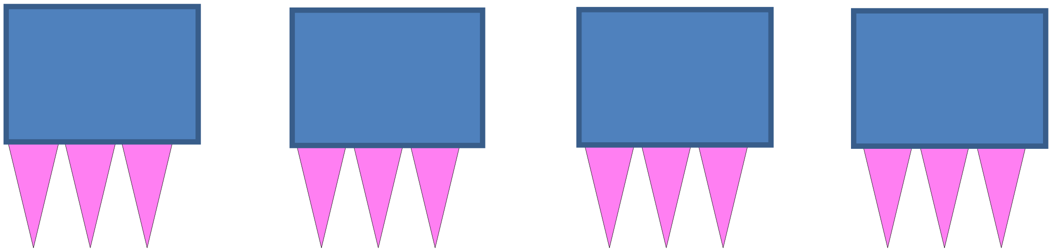
Multiplication example:

2 x 3 =



Division example:

12 ÷ 4 =



Appendix E

Daily Tests during Intervention Period
Teaching Mathematics: Serving Students with Learning Disabilities
Washington State University
Department of Teaching & Learning

1st day	**2nd day**	**3rd day**
2 x 1 = ☐	3 x 2 = ☐	4 x 1 = ☐
☐ x 2 = 4	3 x ☐ = 9	☐ x 4 = 8
2 x ☐ = 6	3 x ☐ = 3	3 x 4 = ☐
2 x 4 = ☐	4 x ☐ = 12	4 x 0 = ☐
3 ÷ 3 = ☐	10 ÷ 5 = ☐	7 ÷ 7 = ☐
10 ÷ ☐ = 2	2 ÷ ☐ = 2	8 ÷ 2 = ☐
12 ÷ ☐ = 4	5 ÷ 5 = ☐	6 ÷ 1 = ☐
4÷ ☐ = 1	8 ÷ ☐ = 4	8 ÷ 4 = ☐

4th day	**5th day**	**6th day**
5 x 0 = ☐	☐ x 3 = 9	☐ x 1 = 4
5 x ☐ = 5	3 x 4 = ☐	4 x ☐ = 15
5 x ☐ = 10	3 x ☐ = 6	2 x 4 = ☐
3 x ☐ = 6	4 x 3 = ☐	☐ x 4 = 12
6 ÷ ☐ = 6	12 ÷ 3 = ☐	20 ÷ ☐ = 5
5 ÷ ☐ = 1	4 ÷ 4 = ☐	4 ÷ 1 = ☐
6 ÷ ☐ = 2	12 ÷ 3 = ☐	10 ÷ 2 = ☐

6 ÷ 6 = □

3 ÷ 1 = □

5 ÷ 5 = □

7th day

5 x 1 = □

□ x 2 = 10

5 x □ = 0

3 x 2 = □

6 ÷ 3 = □

7 ÷ □ = 7

8 ÷ □ = 4

10 ÷ 5 = □

8th day

3 x 3 = □

3 x □ = 12

2 x □ = 6

4 x □ = 12

8 ÷ 2 = □

3 ÷ 1 = □

4 ÷ 4 = □

9 ÷ 3= □

9th day

4 x 0 = □

□ x 4 = 8

3 x 4 = □

1 x 4 = □

10 ÷ 1 = □

6 ÷ 2 = □

4 ÷ □ = 4

12 ÷ □ = 1

10th day

2 x 2 = □

2 x □ = 1

□ x 3 = 6

□ x 4 = 8

4 ÷ □ = 2

6 x □ = 6

3 ÷ 3 = □

2 ÷ 2 = □

11th day

□ x 3 = 12

3 x 3 = □

2 x □ = 6

1 x □ = 3

10 ÷ 2 = □

12 ÷ 3 = □

9 ÷ 3 = □

7 ÷ □ = 1

12th day

□ x 4 = 8

1 x □ = 4

4 x 0 = □

4 x 3 = □

3 ÷ 3 = □

20 ÷ □ = 5

5 ÷ 1 = □

4 ÷ □ = 2

Appendix F

Post-Test
Teaching Mathematics: Serving Students with Learning Disabilities
Washington State University
Department of Teaching & Learning

The purpose of this test is to assess mathematical numerical understanding over a five-day period to determine a baseline level of mathematical ability. It will take about 15-30 minutes to complete the test. If your parents and you agree to participate in this study, please sign the consent form and assent form. Please return the completed test and signed forms to your classroom teacher. Thanks for your participation!

Background Information

School Name ________________________

Which grade are you in? ___________________________

Gender? ☐ **Male** ☐ **Female**

What is your Ethnicity? ☐ **Jordanian**

☐ **Other**

What is your parents' highest level of education?

☐ **Some High School** ☐ **High School**

☐ **Some College** ☐ **College Degree**

☐ **Graduate/Professional (e.g. MA, Ph.D)**

Other (please specify) _____________________

Please answer the questions in the designed box ☐

First Session:	**Second Session:**
3 x 2 = ☐	3 ÷ 1 = ☐
12 ÷ 3 = ☐	3 ÷ 3 = ☐
12 ÷ 4 = ☐	10 ÷ 2 = ☐
12 ÷ 3 = ☐	9 ÷ ☐ = 3
10 ÷ 5 = ☐	5 x ☐ = 10
1 x 3 = ☐	3 x ☐= 3
4x 2= ☐	5 x 3= ☐
☐÷ 4= 2	☐ x 5 = 10

Appendix G

Social Appropriateness of Procedures and Effects
Teaching Mathematics: Serving Students with Learning Disabilities
Washington State University
Department of Teaching & Learning

Additional research questions:

a. Is it hard to learn mathematics?

b. Why is mathematics hard? What was the most difficult part? Why?

c. What things do you usually do in maths time?

d. How did you solve the problem? What did you do?

e. What did you learn today?

f. How are adding and multiplying the same? Would this work every time?

g. When do you use this mathematics at home? At school? In other places?

h. How is this like something you have done before?

Note: This file attachment will be translated to Arabic language by a certified translator.

MEMORANDUM

TO: Ani Derderian
Teaching and Learning, WSU Pullman

FROM: Malathi Jandhyala(for) Matt Layton, M.D., Chair, WSU Institutional Review Board (3005)

DATE: 10/19/2012

SUBJECT: Approved Human Subjects New, IRB Number #12760-001

Your Human Subjects Review Summary Form and additional information provided for the proposal titled "Teaching Mathematics to Students with Learning Disabilities and Studying That Instruction Using A Single Subject Design Approach", IRB File Number 12760-001 was reviewed for the protection of the subjects participating in the study. Based on the information received from you, the WSU-IRB approved your human subjects protocol on 10/19/2012. This protocol is given Expedited review category.

IRB approval indicates that the study protocol as presented in the Human Subjects Form by the investigator, is designed to adequately protect the subjects participating in the study. This approval does not relieve the investigator from the responsibility of providing continuing attention to ethical considerations involved in the utilization of human subjects participating in the study.

This approval expires on 10/18/2013. If any significant changes are made to the study protocol you must notify the IRB before implementation. Request for modification forms are available online at http://www.irb.wsu.edu/forms.asp.

In accordance with federal regulations, this approval letter and a copy of the approved protocol must be kept with any copies of signed consent forms by the principal investigator for THREE years after completion of the project.

Washington State University is covered under Human Subjects Assurance Number FWA00002946 which is on file with the Office for Human Research Protections.

If you have questions, please contact the Institutional Review Board at (509) 335-3668. Any revised materials can be mailed to the Office of Research Assurances (Campus Zip 3005), faxed to (509) 335-6410, or in some cases by electronic mail, to irb@mail.wsu.edu.

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مدرسة المشرق الدولية
Mashrek International School

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Mashrek International School Mission Statement

Our mission is to teach students critical thinking, international understanding and appreciation of diversity while preserving the Arabic culture. Mashrek raises the individuals to become proud of their identity, responsible, and productive citizens in their country and the whole world as well.

International Baccalaureate Mission Statement

"The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.

To this end the organization works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.

These programmes encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right."

Special Educational Needs Department Mission Statement

The SEN department is keen on supporting those with different learning methods and styles, by placing them in a regular classroom and allowing them to reach their full academic, emotional and social potential.

Philosophy of Special Education Needs Department

The SEN department at Mashrek International School abides by the Jordanian Ministry of Education laws and regulations, protecting the special needs students under the provisions of Jordanian law. Mashrek International School implements the 3 IB programmes which objectives coincide with our own in terms of encouraging students to think critically, inquire and learn deeply, develop their sense of belonging and communicate with peoples of other cultures with respect and understanding.

The SEN Department works to develop students' performance based on the IB program requirements through the following steps:

- SEN students acquire all the IB skills, attitudes, characteristics and strategies with the proper modifications that are appropriate for their abilities.
- SEN students participate in learning activities and follow instructional strategies normally and spontaneously within the classroom environment.
- Focus on collaborative effort of different teachers to develop students' performance instead of having an SEN teacher within the classroom.
- Focus on whole student development through:

- Affirming identity and building self-esteem
- Valuing prior knowledge
- Scaffolding
- Extended learning

SEN Department Timeline

The SEN department was established in 1993 at Mashrek International School and the services provided were based on individualized education in the resource rooms supervised by specialists outside the regular classroom.

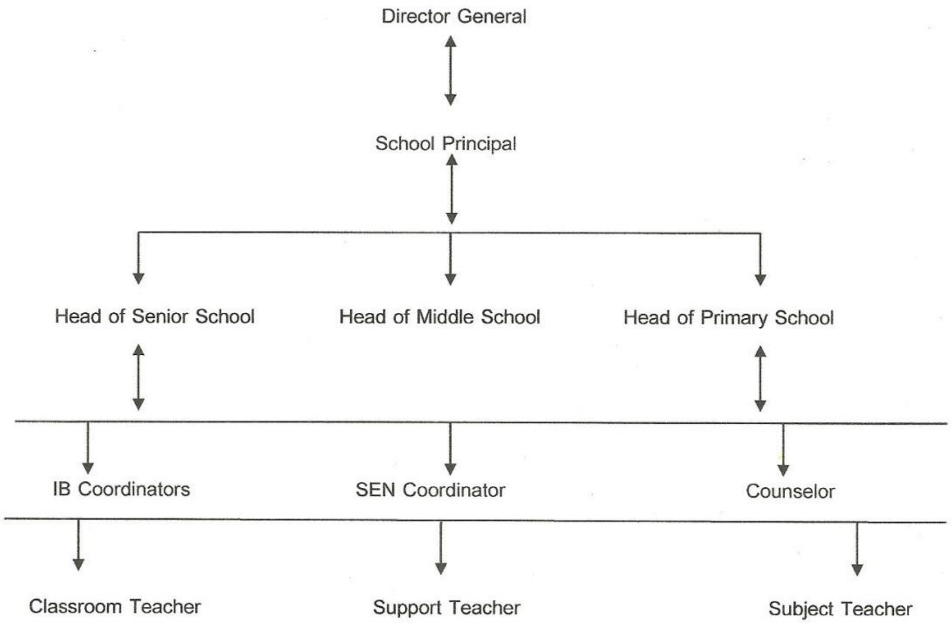
By 1997-1998, the school went into the transition to integrate SEN students in their classroom while retaining an SEN teacher to support them. The resource rooms were used in some special cases or as needed.

By 2006-2007, the school adopted the full integration of students within their classroom with an SEN teacher in certain lessons, based on the Individual Educational Plan (IEP) requirements with modifications in teaching methods, learning strategies and assessments.

In 2011-2012, due to the technological development and information revolution in our society which lead to the progress of the current curriculum with all its components and goals. Learning in the 21st century became holistic and based on real life situations, thus, empowering our students to develop new personal and behavioral patterns adequate for the 21st century.

Therefore, the SEN department is heading towards a new technique of teaching with SEN students. This new technique encompasses a collaborating team of special needs teachers and classroom/subject teachers to support learning strategies and assessments provided for students, each according to his/her needs in a normal and collaborative learning environment.

Organizational Structure of the Special Educational Needs Department



Standard Procedures for the SEN Department

SEN follows a series of procedures aiming to discover the difficulties or problems that the student faces within the classroom and to look for learning strategies that meet these abilities and needs of the student within the classroom, through offering the service of learning support by a team that consists of the Classroom teacher, the SEN teacher and the Counselor.

The procedure:

Phase 1:

1) Observation
2) General prognosis, identification and recognition
   - Recording behavioral and academic observations
   - Filling the learning difficulties checklist
   - Discussing the observational notes with the team
   - Students with academic and/or behavioral problems will move to the next procedure which is diagnosis.
3) Specialized identification : Done by SEN teachers using special strategies
4) Diagnosis: It is an extended and detailed procedure applied to students who have been diagnosed with learning difficulties, as it identifies the type of inability, the causes and suggested interventions.

The diagnostic assessments applied by the SEN team are:

- Academic Assessments: Academic tests aiming to identify the student's current performance in the basic skills in Arabic, English and Math.

- Cognitive Assessments: Assessments aiming to determine whether the student has the minimum level that would allow him/ her to go through to the next required level.

- Checklists: pertaining to social and behavioral skills

The process of diagnosis involves the following:

1) Academic Assessments (Arabic , English and Math)
2) Cognitive Assessments
3) Filling checklists of the academic and social aspects
4) Preparing a report involving academic, cognitive, behavioral and social aspects as well as recommendations concerning the student's current performance.

5) Severe cases will be referred to external specialized centers.

Phase 2: Decision making will be based on the report and the SEN staff's opinion. The student will be referred to the appropriate department, whether it was the SEN, Counseling or a specialized expert.

Phase 3:

The Intervention Program: The SEN strategy is based on making the learning process easier for the students who have been diagnosed with special educational needs in order to help them achieve their full potential, have more positive interaction with their peers and be able to take responsibility of their learning. The SEN teacher makes the proper modifications to the unit plan and assignments, in addition to recommending strategies to the classroom teacher to provide an atmosphere that suits the student's academic and behavioral needs.

The Intervention Program procedures in the Primary school involve the following steps:

Planning: The SEN teacher in cooperation with the Classroom/Subject teacher modifies/ adds tools and strategies that suit the interests and potential of the student and his/her learning pattern.

This is done by:

1. Modifying the unit plans prepared by the classroom teacher for Primary Years Program (PYP) and Middle Years Program (MYP) students.
2. The SEN teacher prepares an Individual Educational Plan (IEP) for cases requiring intensive training on skills that should enable the student to achieve the essential objectives and goals.
3. Providing a suitable environment for SEN students, considering their visual and auditory levels.

Implementation: After Planning, the classroom teacher should focus on applying the suggested strategies that would reinforce the learning and teaching process, taking into consideration the individual differences.

The Implementation process involves the following parties:

Classroom teacher:

- Demonstrating knowledge for the students using specific ideas and vocabulary.
- Analyzing the skills that would help in achieving the proper learning outputs.
- Applying concepts through making use of previously acquired knowledge and connecting it in a new and practical way.
- Providing the proper tools to assist students with their specific skill based assignments.
- Participating in determining the proper tools and strategies for the assessments and providing assistance during evaluation.

- Offering feedback and clarifying the degree of connecting newly acquired to previously acquired knowledge

SEN teacher:

- Helps and supports the classroom teacher while implementing the plan in class.
- Observes how the student reacts to the current unit plan.
- Makes sure that the plan is properly implemented, focusing on the organizational procedures for each unit plan.
- Provides help to ensure continuous skills and performance development.
- Prepares all needed materials and tools needed for the development of the desired skills.
- Cooperates with class/subject teacher in teaching skills that need special intervention.
- Cooperates with class/subject teacher in the evaluator procedures.
- Follows up the student's developmental portfolio.

Counselor:

- Prepares framework of necessary guidance plans in cooperation with the SEN teacher.
- Follows up on the student's academic and behavioral development and provides counseling to achieve the designed objectives.
- Puts behavior support plans in place to help the student's interaction within the school community.
- Bridges between school and home and keeps guardians informed about their child's progress.
- Observes student's relationships and interactions within the school community to identify challenges, and offers help to allow for social merging within the school community.

Phase 4:

Feedback: Feedback is considered a positive and comprehensive reflection that leads the student and the teacher to assess their performances. Through feedback, the teacher is able to evaluate the cognitive, educational and behavioral strengths and limitations of the student and plans accordingly to ensure modification of performance.

SEN TEAM

SEN services are based on continuous, comprehensive and supportive programs, and it is the resultant of a specialized and cooperative team of varied expertise. This team's work involves the interpretation the different aspects of the child's assessments; physical, motor, sensory, linguistic, emotional and social by using various methods and tools to identify and cater to those needs.

The SEN team comprise a group of bachelor degree holders in special education; qualified to teach Arabic, Math and English based on the strategies and needs of SEN students.

SEN Department Tasks:

Department Coordinator:

- Coordinates, supervises and plans for a better output.
- Follows up the procedures and diagnosis for the referral of students.
- Provides the Classroom teacher with the SEN students' names, explaining their cases.
- Coordinates with the class/subject teacher on how to deal with and encourage the SEN students.
- Participates in the regular meetings of the SEN Department to discuss the unit plans and the assessments of students.
- Coordinates with the Counseling Department regarding behavioral cases.
- Coordinates the tasks of the SEN Department with other departments within and outside the school
- Prepares for the regular meetings with SEN teachers to discuss students' cases and offers recommendations to ease the working process.
- Coordinates meetings with parents and SEN teachers.

SEN teacher:

- Participates in the observation of the cases that require academic, behavioral and emotional support.
- Applies the diagnostic tests (Arabic, English, and Math)

- Evaluates the student's current level of performance by pointing out his/her strengths and limitations.
- Prepares the diagnostic report, mentioning the challenges and recommendations to be discussed with the rest of the team.
- Participates in the modification of the unit planner worksheets for core subjects.
- Effectively cooperates with the class/subject teacher to monitor the student's development through offering the proper support and strategies.
- Applies the IEP in some cases based on effective and varied strategies.
- Participates in evaluating the students through tools that suit their academic, social and emotional abilities.

Routine Tasks for SEN teachers:

- Spread awareness and understanding in the school community on how to deal with SEN students.
- Reinforce the positive interaction between SEN students and other students.
- Establish positive relationship parents/guardians.
- Prepare learning tools and additional worksheets that suit the student's abilities.
- Monitor the student's performance in class/homework assignments.
- Supervise the student's evaluation in all the subjects.
- Attend the Departments routine meetings.

Relationship between the SEN teacher and Class/Subject teacher:

- Cooperatively observe the cases that need academic, behavioral and emotional evaluation
- Provides the class/subject teacher with a list of SEN students.
- Cooperatively modify unit plans.
- Assists the class/subject teacher in understanding the characteristics of each student, taking individual differences and developmental stage into consideration.
- Provides consultation for the class/subject teacher by providing strategies and tools that are appropriate for the student's abilities.
- Contributes suitable materials and proper tools which should lead to understanding concepts and achieving the student's required level of performance.
- Assists the class/subject teacher in assigning the required subject matter and important skills to be achieved.
- Decides with the class/subject teacher proper & appropriate assessment tools that meet the student's abilities.
- Cooperatively modify the assessment tasks of the SEN student.

Services offered by the SEN department:

- Spread awareness and understanding in the school community about SEN students.
- Develop the skills, attitudes and characteristics of the IB student.
- Inform parents/ guardians of the various local centers that can be helpful.
- Apply the standard prognostic and diagnostic procedure to evaluate a student's needs.
- Inform the teaching staff about SEN students.
- Modify the unit plans according to student's abilities
- Preparing IEP for certain cases.
- Monitor and facilitate the educational process of SEN students in all subjects inside the classroom.
- Preparing a special file for each student with the following documents:
    - Classroom schedule
    - Observational report
    - Diagnostic tests
    - Modified copies of the unit plan and student tasks
    - IEP for special cases
    - Copy of modified assessments

SEN services are offered to:

- Students diagnosed with learning difficulties (reading, writing, and/or math)
- Students with attention deficit hyperactivity disorder (ADHD).

SEN Assessments:

- The goal of the assessment is to reveal the level of the student's abilities without placing him/her in a competitive environment.
- The SEN teacher works with the class/subject teacher to modify the assessment if the student is able to cope with the class curriculum or part of it.
- Assessment tools are modified to match the student's abilities and the goals of the assessments.
- The Class/subject teacher formatively assesses students by presenting worksheets suitable for their abilities inside the classroom to achieve the required goals.
- The summative assessment is carried out after practicing and giving suffice feedback in many different forms.
- Two portfolios that represent the different work/performance and evaluation of each student are kept in the school; one with the Coordinator of the SEN department and the other with the class/subject teacher.
- When feedback about the student's performance indicates good progress that enables him/her to cope with the objectives of the grade level, then, SEN services are gradually withdrawn. Also, the modification of assessments is gradually eliminated.

Shadow teacher

Is a teacher, who is available to a student whose disorder prevents him/her from working alone. The teacher assists the student to achieve the necessary skills for working independently within the classroom; this is done by clarifying difficult concepts while taking attention span into consideration and working to expand it.

Working hours: The Shadow teacher expected to work 40 hours weekly from Sunday until Thursday, starting 7:30 am until 3:00 pm.

Nature of work: Accompanies the student while inside and outside the classroom during the school day, and cooperates with the SEN department, Head of School, and class/subject teachers, in addition to helping the SEN student with homework and classwork.

Job contract:

- The shadow teacher is assigned and paid by the parents/guardians of the SEN student.
- The Shadow teacher abides by all the regulations applied by the school administration concerning attendance, absence, and tardiness.
- The Shadow teacher is obliged to attend the meetings assigned by the SEN Department or the school, if they concern the student's interests.
- In case of the student is absent, the Shadow teacher is obliged to attend school and work on preparing worksheets, tasks and assessment tools for the student.If the student is absent for a prolonged period of time, coordination will take place between parents, teacher and the school.

Tasks of the shadow teacher:

- Tasks carried out by the shadow teacher concern the student, parents/guardians, and the SEN department.

Tasks concerning the student:

- Prepares an IEP that is suitable for the student's academic, psychological, and social needs.
- Assists the student to focus within the classroom.
- Helps the student to participate adequately inside the classroom.
- Encourages student to ask for teacher/peers help when needed.
- Assist the student to share his/her own interests with peers.
- Develop the student's communication proficiency by providing the training for effective communication skills, and encouraging taking dialogue initiative.
- Helps the student to respond properly towards his peers in the social situation.
- Develops the student's concept of independence inside and outside the classroom.
- Supervises the student within the school and provides a safe environment.
- Encourages the development of the student's personality and raises self-esteem.
- Facilitates positive interactions between student and peers.
- Assists in the development of emotional growth of the student.
- Assists the student to participate in programs and activities both inside and outside the classroom.

Administrative Tasks:

- Keeping records to show the academic progress of the student.
- Applying of diagnostic tests on the student (basic Arabic Language & Mathematical skills).
- Determining the current performance level of the student by identifying strengths and limitations.
- Writing a diagnostic report indicating the type of difficulty experienced by the student and the recommendations.
- Preparing an IEP for special cases, as needed.
- Modifying the content of the material in parallel with the IEP and the student's capabilities.
- Effectively coordinating with the class/subject teacher whenever necessary.
- Implementing of the IEP according to a variety of effective learning methods and strategies.
- Assessing student's abilities in ways that suit his/her academic, social and emotional needs.
- Promoting positive interaction among students with special needs and other students.
- Developing and using educational tools that suit the capabilities of the student.
- Following-up on homework and classwork assignments.
- Overseeing the evaluation of the student in all subjects.
- Attending periodical meetings of the department.

Tasks related to parents:

- Establish a positive relationship and regular contact with parents concerning instructional and educational programs available in the school.
- Provide a daily report to parent/guardian, of what has been covered with the student during the school day on a special agenda.

ملحق ا

نموذج موافقة المشاركة في البحث

تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم

جامعة ولاية واشنطن

كلية التعليم والتعلم

12760-001

Additional material

الباحثه: آني دردريان، طالبة دكتوراه في كلية التعليم والتعلم، هاتف ٦٨٤٢-٣٣٥-٥٠٩، بريد الكتروني aderderian@wsu.edu

هدف الدراسة: صممت هذه الدراسة للبحث في مجال كبير لم يكتشف من استراتيجيات التدريس مثل الملخص التصويري الملموس لطلبة صعوبات التعلم في الرياضيات.

-الإجراء: اعطى مديرك اذنا بهذه الدراسة .تم دعوة الطلبة من ذوي صعوبات التعلم للمشاركة في هذه الدراسة. إذا وافقت ووافق طفلك على المشاركة، سيتم الطلب من طفلك ليكون جزءا من هذه الدراسة. يحتاج الطلبة إلى انهاء الفترة التدريبية وإنهاء الاختبارات اليومية وإحضار نموذج الموافقة الموقع ونموذج القبول إلى مدرسي صفوفهم. سيكون التدريب على المفاهيم الرقمية وستكون اسئلة الاختبار حول وقائع الضرب والقسمة إلى ١٢.

المنافع: ستساعد المعلومات التي تم جمعها في هذه الدراسة الطلبة ذوي صعوبات تعلم الرياضيات والمدرسين والباحثين لفهم الرياضيات بشكل افضل.

المخاطر: هناك بعض المخاطر لك ولطفلك في حالة موافقتك على المشاركة في هذه الدراسة .في حالة عدم ارتياحك لأي سؤال من اسئلة الاختبار فلك الخيار بعدم الاجابة على ذلك السؤال.

الطبيعة الطوعية للمشاركة:تعد مشاركتك في هذه الدراسة تطوعا بشكل كلي . يحق لك أن تقرر في أي مرحله زمنية التوقف عن المشاركة دون أي غرامة

السرية: سيتم المحافظة على السرية التامه بالنسبة لجميع المعلومات التي يتم الحصول عليها منك، سيتم اعطاؤك رقم هوية وستدخل اجوبتك في ملف بيانات يحتوي فقط على رقم هويتك وليس اسمك. وستبقى هوية طفلك في جميع النتائج المنشورة.

تصريح الموافقة:

تم شرح هذه الدراسة لي ولطفلي . تطوعت انا وطفلي للمشاركة في هذا البحث. لدي الفرصة لأسال اسئلة إذا كان لدي اسئلة عامة حول البحث، استطيع أن اسال الباحثون المدرجة اسماؤهم اعلاه . إذا كان لدي اسئلة بالنسبة لحقوقي كمشارك، استطيع أن اتصل بمجلس المراجعة المؤسسي لجامعة واشنطن على هاتف ٩٦٦١-٣٣٥ (٥٠٩) ثم مراجعة واعتماد هذا المشروع للمشاركة الانسانية من قبل

سأحصل على نسخة نموذج الموافقة.

توقيع والد المشترك الاسم كاملا (يرجى طباعته) التاريخ

١

٦٩٢٣٦٢
Tel. 692362
Amman
Office

ملحق ب

نموذج قبول المشاركة في البحث

تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم

جامعة ولاية واشنطن

كلية التعليم والتعلم

الباحثه: آني دردريان، طالبة دكتوراه في كلية التعليم والتعلم، هاتف ٦٨٤٢-٣٣٥-٥٠٩، بريد الكتروني aderderian@wsu.edu

نقوم بدراسة بحثية حول تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم. الدراسة البحثية هي طريقة للتعلم أكثر حول الطرق التدريسية لمساعدة الطلبة. في حالة ما قررت بأن لديك الرغبة لتكون جزءاً من هذه الدراسة، فإنه سيطلب منك لإنهاء فترة تدريبه قدرها ٤ اسابيع بواقع ٤٥ دقيقة لكل يوم.

اعطى مديرك الموافقة على هذه الدراسة . طلبه المدرسة الابتدائية مدعوون للمشاركة في هذه الدراسة.

في حالة موافقتك على المشاركة سيطلب منك حضور التدريب وإنهاء اختبارات . تحتاج لعمل اختبارات. احضر نموذج الموافقة الموقع ونموذج القبول الموقع إلى مدرس صفك. سيكون التدريب على المفاهيم الرقمية وستكون اسئلة الاختبار حول وقائع الضرب والقسمة إلى ١٢.

ستساعد المعلومات التي تم جمعها في هذه الدراسة الطلبة ذوي صعوبات تعلم الرياضيات والمدرسين والباحثين لفهم افضل لاستراتيجيات تدريس الرياضيات.بهذه المعلومات، يكون للباحثين صوره افضل عن تدريس وتعلم الطلبة للرياضيات.

لدى استكمال هذه الدراسة، سنكتب تقريرا حول ما تم تعلمه . لن يتضمن التقرير اسمك أو أنك كنت في الدراسة

لا يجب أن تكون في هذه الدراسة في حالة عدم رغبتك بذلك. إذا قررت التوقف بعد البدء، فلا مانع من ذلك أيضا.

تم مراجعة وموافقة هذه الدراسة من قبل مجلس المراجعة المؤسسي بجامعة ولاية واشنطن (أي ار بي).

إذا كان لديك استفسارات عن هذه الدراسة يرجى الاتصال بالباحث على الرقم ٧٦٥٢-٣٣٥-٥٠٩ .اذا كان لديك اسئلة بالنسبة لحقوقك كمشارك، يرجى الاتصال بمجلس المراجعة المؤسسي لجامعة واشنطن هاتف ٩٦٦١-٣٣٥-٥٠٩ على هاتف

إذا قررت أن تكون في هذه الدراسة ، يرجى توقيع اسمك

انا.............................. ارغب أن اكون في هذه الدراسة البحثية

(اطبع اسمك هنا)

وقع اسمك هنا التاريخ

مكتب الفضاء للترجمة
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ملحق جـ

الاختبار القبلي

تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم

جامعة ولاية واشنطن

كلية التعليم والتعلم

يهدف هذا الاختبار إلى تقييم فهم الارقام الرياضية على مدى فترة خمسة ايام لتحديد مستوى قاعدة الاساس (خط الاساس) للقدرة الرياضيه. سيستغرق حوالي ١٥-٢٠ دقيقة لاستكمال الاختبار. إذا وافق والديك ووافقت على المشاركة في هذه الدراسة يرجى توقيع نموذج الموافقة ونموذج القبول. يرجى اعادة الاختبار المكتمل والنماذج الموقعة إلى مدرس صفك. شكرا لمشاركتك.

معلومات اساسية

اسم المدرسة:..

في اي صف انت...

النوع الاجتماعي ☐ ذكر ☐ انثى

ما هي جنسيتك ☐ اردني

ما مستوى تعليمي لوالديك ☐ اقل من ثانوية ☐ ثانوية

☐ اقل من كلية ☐ كلية

☐ جامعي/متخصص(ماجستير، دكتوراة)

غير ذلك (حدد لطفا) ....

يرجى اجابة الاسئلة في المربع المخصص ☐

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الجلسه الاولى	الجلسه الثانيه	الجلسه الثالثه	الجلسه الرابعه
٣×٤= ☐	٣÷١= ☐	٨÷٤= ☐	١٠÷☐=٢
١٢÷٤=☐	٣÷٣= ☐	٨÷٢= ☐	٣÷ ☐=٣
١٢÷٣=☐	٢٠÷٤=☐	١٢÷٤= ☐	٣÷ ☐= ١
١٥÷٣=☐	٢٠÷ ☐=٤	١٠÷٢=☐	٥÷١=☐
١٥÷٥=☐	٥×☐ = ١٠	٢ ×٥=☐	٦×١=☐
١×٣= ☐	٣×☐ =٣	٦×٢=☐	٦×☐ =٦
٤×٢=☐	٥×٣= ☐	٣×٢=☐	٣×☐ =٦
☐×٤=٢٠	٥ ×☐=١٠	٢×٥= ☐	☐×٥= ٥

ملحق د

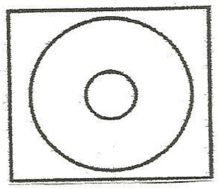
تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم

جامعة ولاية واشنطن

كلية التعليم والتعلم

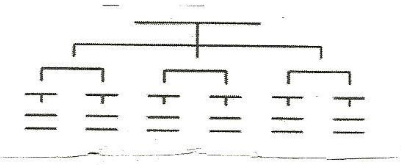
ملخص (خرائط التفكير)

خارطة الدائرة



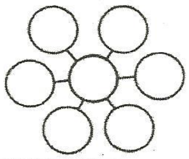
خارطة الشجرة

لتصنيف والتجميع



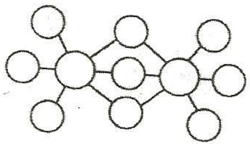
خارطة الفقاعة

لوصف إستخدام الصفات



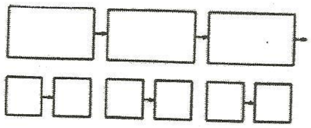
خارطة الفقاعه المزدوجة

للمقارنة و التباين



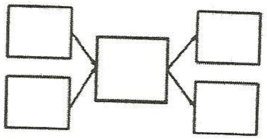
خارطة التدفق

للترتيب والتنظيم



خارطة التدفق المتعددة

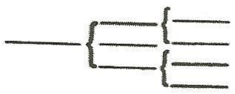
للأسباب والآثار



خارطة الدعامة

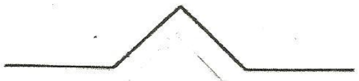
لتحليل جميع الاهداف والأجزاء

تم تبنيها من: الادوات البصرية التي تعمل



خارطة الجسر

لبحث المتماثلات

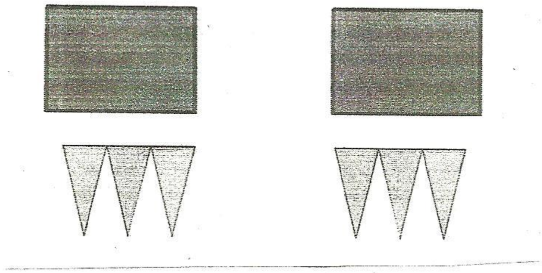


٥

امثلة من استراتيجية (خارطة التفكير) الملخص التصويري الملموس

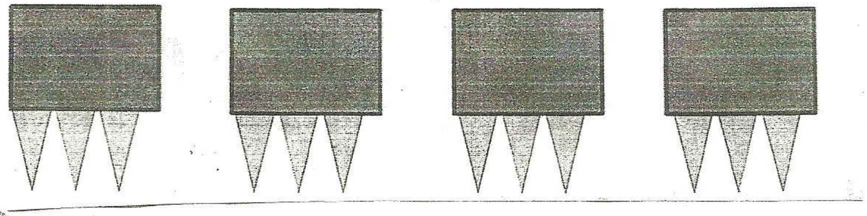
مثال ضرب

=3×2



مثال قسمه

=4÷12



الملحق هـ

اختبارات يومية خلال فترة التدخل

تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم

جامعة ولاية واشنطن

كلية التعليم والتعلم

اليوم الاول

٢×١=□

□×٢=٤

٢×□ =٦

٢×٤=□

٣÷٣= □

١٠÷□ =٢

١٢÷□ =٤

٤÷□=١

اليوم الثاني

٣×٢= □

٣×□ =٩

٣×□ =٣

٤×□ =١٢

١٠÷٥= □

٢÷ □ =٢

٥÷٥=□

٨÷□ =٤

اليوم الثالث

٤×١ =□

□×٤=٨

٣×٤=□

٤×٠=□

٧÷٧=□

٨÷٢=□

٦÷١=□

٨÷٤=□

اليوم الرابع

٥×٠=□

٥×□ =٥

٥×□ =١٠

٣×□ =٦

٦÷□=٦

اليوم الخامس

□×٣=٩

٣×٤= □

٣×□ = ٦

٤×٣= □

١٢÷٣=□

اليوم السادس

□×١=٤

٤×□ =١٥

٢×٤=□

□×٤=١٢

٢٠÷□ =٥

٥÷□ = ١
٦÷□ =٢
٦÷٦= □

٤÷٤=□
١٢÷٣= □
٣÷١=□

٤÷١=□
١٠÷٢=□
٥÷٥=□

اليوم السابع

٥×١=□
□×٢=١٠
٥×□ =٠
٣×٢= □
٦÷٣= □
٧÷□=٧
٨÷□=٤
١٠÷٥=□

اليوم الثامن

٣×٣=□
٣×□ =١٢
٢×□ =٦
٤×□ =١٢
٨÷٢=□
٣÷١=□
٤÷٤= □
٩÷٣= □

اليوم التاسع

٤×٠=□
□×٤=٨
٣×٤=□
١×٤=□
١٠÷١=□
٦÷٢=□
٤÷□ =٤
١٢ ÷□ =١

اليوم العاشر

٢×٢=□
٢×□ =١
□ ×٣=٦
□ ×٤=٨
٤÷□ =٢
٦÷×□ =٦
٣÷٣= □
٢÷٢= □

اليوم الحادي عشر

□ ×٣=١٢
٣×٣=□
٢×□ =٦
١×□ =٣
١٠÷٢=□
١٢÷٣=□
٩÷٣= □
٧÷□ =١

اليوم الثاني عشر

□ ×٤=٨
١×□ =٤
٤×٠=□
٤×٣=□
٣÷٣=□
٢٠÷□ =٥
٥÷١=□
٤÷□ =٢

ملحق ز

التناسب الاجتماعي للإجراءات والآثار

تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم

جامعة ولاية واشنطن

كلية التعليم والتعلم

اسئلة بحث اضافية

أ-   هل هناك صعوبة في تعلم الرياضيات؟

ب- لماذا الرياضيات صعبة؟ ما هو الجزء الذي كان أكثر صعوبة ؟. لماذا ؟

جـ- ما هي الأشياء التي تعملها في العاده في وقت الرياضيات؟

د- كيف تحل المشكلة؟ ماذا تعمل؟

هـ- ماذا تعلمت اليوم؟

و- هل الجمع والضرب متشابهان؟ هل هذا العمل كل مرة ؟

ز- متى تستخدم هذه الرياضيات في المنزل؟ في المدرسة؟ في اماكن أخرى؟

ح- هل هذا يشبه شيئا ما عملته سابقا؟

ملاحظة:سيتم ترجمة الملف المرفق الى اللغة العربية من مترجم معتمد

مكتب الفضاء للترجمة
عمان
هاتف [illegible]
Tel. [illegible]62
Amman
Space Translation Office

ملحق ح

الاختبارالبعدي

تدريس الرياضيات: خدمة الطلبة ذوي صعوبات التعلم

جامعة ولاية واشنطن

كلية التعليم والتعلم

يهدف هذا الاختبار إلى تقييم فهم الارقام الرياضية على مدى فترة خمسة ايام لتحديد مستوى قاعدة الاساس (خط الاساس) للقدرة الرياضيه. سيستغرق حوالي ١٥-٢٠ دقيقة لاستكمال الاختبار. إذا وافق والديك ووافقت على المشاركة في هذه الدراسة يرجى توقيع نموذج الموافقة ونموذج القبول. يرجى اعادة الاختبار المكتمل والنماذج الموقعة إلى مدرس صفك. شكرا لمشاركتك.

معلومات اساسية

اسم المدرسة:...

في اي صف انت...

النوع الاجتماعي ☐ذكر ☐ انثى

ما هي جنسيتك ☐ اردني

ما مستوى تعليمي لوالديك ☐اقل من ثانوية ☐ثانوية

☐اقل من كلية ☐كلية

☐ جامعي/متخصص(ماجستير، دكتوراة)

غير ذلك (حدد لطفا) ....

يرجى اجابة الاسئلة في المربع المخصص ☐

Space Translation Office
Amman

الجلسه الاولى	**الجلسه التانيه**
٣×٢= □	٣÷١= □
١٢÷٣=□	٣÷٣=□
١٢÷٤= □	١٠÷٢=□
١٢÷٣= □	٩ ÷ □=٣
١٠÷٥= □	٥×□ = ١٠
١×٣= □	٣×□ =٣
٤×٢=□	٥×٣=□
□÷٤=٢	□ ×٥=١٠

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